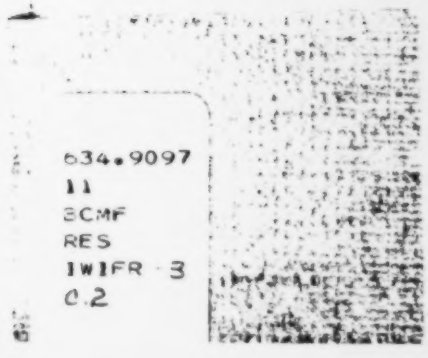
APPLYING ECOLOGICAL CLASSIFICATION SYSTEMS
TO WILDLIFE RESEARCH AND MANAGEMENT

INTEGRATED WILDLIFE INTENSIVE FORESTRY RESEARCH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APPLYING ECOLOGICAL CLASSIFICATION SYSTEMS TO WILDLIFE RESEARCH AND MANAGEMENT

A problem analysis

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Province of
British Columbia

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SUMMARY

The objectives of the problem analysis were to determine which needs of forest wildlife researchers and managers could be met by an ecological classification system, to describe existing classification systems, and to assess how well they meet those needs. Information needs were determined through interviews with members of the Technical Working Group of the Integrated Wildlife-Intensive Forestry Research program. The group requires a natural ecological classification system as the framework for research and management, and as the basis for more technical classifications of wildlife habitat and capability. The classification system should be applicable to large-scale mapping and should provide units that are homogeneous in their response to forest management practices. The mapping system should show existing vegetation, and the classification system should provide a framework for predicting structure and species composition of seral stages resulting from forestry practices. Units should be as uniform as possible with respect to attributes that are important to wildlife, and should be characterized in terms of these attributes. The classification system should be adaptable to new information and new management objectives.

The classification systems that were described were those used in the ecosystem classification program of the Ministry of Forests (Vancouver Forest Region), the biophysical classification program of the Terrestrial Studies Branch, Ministry of Environment, and the soil-vegetation classification developed by Moon and Selby of Agriculture Canada. As many of the proposed criteria require field studies for evaluation, the problem analysis did not reach an overall conclusion about which classificaton system is most suitable for application to wildlife research and management. Many of the needs of wildlife biologists are the same as the needs of other users of classification systems. Classification systems have not been evaluated in terms of their success in meeting the more general objectives for which they were developed. In view of the cost and the importance of ecological classification, a broad-based evaluation of classification systems is recommended.

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I. RATIONALE AND OBJECTIVES

The Integrated Wildlife-Intensive Forestry Research Program (IWIFR) of the Ministries of Forests and Environment is presently developing a major research plan, with the goal of providing information needed for effective integration of forest and wildlife management on Vancouver Island. The central concern of the research will be the investigation of relationships between intensive forest management practices and wildlife. As Vancouver Island comprises a variety of ecologically different forest habitats, it is essential that such a research program be carried out within the framework of an ecological classification system.

Several ecological classification systems are presently being applied on the island by government agencies and private forest companies. In general, these systems have been developed to meet objectives that are not explicitly related to wildlife. Their applicability to wildlife research and management is largely unexamined. Furthermore, these ecological classification systems are not well understood by many wildlife biologists, in part because of the lack of comprehensive publications describing them.

There appears to be a two-way information gap. Persons involved in wildlife habitat management have inadequate information about ecological classification systems, and persons involved in classification have inadequate information about the needs of wildlife managers.

The objectives of the problem analysis are:

1. To determine the information needs of forest wildlife managers and researchers that could be met by an ecological classification system.
2. To describe the classification systems that are presently in use, or available for use, on Vancouver Island.

3. To assess existing classification systems in terms of their ability to meet the needs of forest wildlife managers and researchers, or to recommend approaches to such an assessment.

Classification systems are considered here in terms of their scientific value to managers and researchers. Extrinsic factors, such as the political consequences of adopting the system used by a particular agency, are outside the scope of the problem analysis.

II. OVERVIEW OF CLASSIFICATION SYSTEMS

The purposes of this overview are to discuss some of the variations in approach used in the classification of land and land resources, and to review some of the projects in which classification systems have been related to wildlife habitat.

Classification is the process of arranging objects into groups on the basis of their similarities or relationships. The product of this process is also called a classification, or a classification system (Bailey et al. 1978). The recognition of unknown objects by means of a classification system, as through the use of a key, is identification. The principal purpose of any classification is to describe and simplify the relationships of the constituent objects in such a way that general statements can be made about classes of objects (Sokal 1974).

Classification, a process of logical grouping, is different from mapping, a process of spatial representation. However, a classification system is implicit in any map which delineates areas, rather than merely identifying points. Ecological map units may correspond directly to the units of an ecological classification system, as in V.J. Krajina's (1973) well-known map, "Biogeoclimatic zones of British Columbia". Or, map units may be related to the units of an ecological classification system in a more complex way. For example, they may represent groupings of classification units that cannot be distinguished at the chosen map scale, or they may represent consistently recurring combinations of classification units.

Classification systems must also be distinguished from information systems (Davis and Henderson 1978). A land classification system defines land units, but may provide little information about them beyond what is necessary to

distinguish one from another. An associated information system stores, manipulates, and retrieves information about the land units - for example, it may handle a growing set of data about the responses of the land units to management practices. Consideration of information systems *per se* is outside the scope of this problem analysis, but some classification systems that are associated with information systems are discussed below.

For any set of objects, there are many alternative arrangements which meet the logical requirements of a classification (Williams 1967). Some of these will be suited to specialized purposes, whereas others lend themselves to general application. The development of a classification for specialized or general purposes may be approached in a variety of ways.

APPROACHES TO CLASSIFICATION

Classifications vary in their degree of information synthesis (Davis and Henderson 1978). At one extreme along this scale are classifications of that set of biophysical components of land which are measurable, quantifiable, or identifiable. Davis and Henderson (1978) list bedrock, regolith, soil, climate, topography, potential vegetation, and water as the permanent components and current vegetation, current animals, physical development (roads, buildings) and human organization (ownership, use) as the temporal components of land. Each of these components can be used as a basis for classification. Identification of a site involves the assignment of a class for each of the components. Davis and Henderson (1978) comment that, taken together, the components include for each environment virtually all the characteristics which can be seen, identified, counted and measured. However, each component classification, like any other classification, is based on a selected set of attributes. Those attributes which are not selected as a basis for classification are not reflected in the system, and are not necessarily correlated with the final classification units.

Intermediate on the scale of information synthesis are integrated classifications, which are based on two or more components. An example of an integrated classification would be one produced by overlaying a vegetation map and a soil map, and recognizing the new classes formed by the integration. As described by Davis and Henderson (1978), integrated classifications are based strictly on separate component classifications, and the rules of integration are explicitly stated. However, classifications in which two or more environmental components are analyzed simultaneously, and classifications in which the rules of integration are not explicit, may also be considered integrated. Integrated classifications of the latter sort differ far more fundamentally from component classifications than do integrated classifications in the sense of Davis and Henderson (1978).

At the other extreme along the scale of information synthesis are technical, or interpretive classifications. Technical classifications -- such as capability classifications - are groupings of objects according to their value for some specific purpose (Cline 1949). They may be based on integrated or component classifications, or may be related directly to the land base. The rules and assumptions which relate the interpretive classification either to the land base or to less synthetic classifications may or may not be explicit.

Many writers have distinguished between classifications that are technical (or artificial), and those that are natural (or taxonomic). According to Cline (1949), natural classifications are based on natural relationships and serve a large number of purposes. The connotations and vagueness of the phrase "natural relationships" make this definition difficult to apply. In this problem analysis, a classification that serves a single, specific purpose is considered to be technical, and one that serves a variety of purposes is considered natural. Either component or integrated classifications may be natural.

What makes a classification suitable for a large number of purposes? Classifications that are constructed on the basis of a single factor (monothetic), such as a classification based on forest site index, are generally limited in their application. In contrast, classifications that are based on many factors (polythetic) are more likely to be correlated with other attributes, and are thus more natural than single-factor classifications (Bailey et al. 1978). Classifications that are based on many factors do not necessarily require that many factors be used for identification. Keys and other identification tools may be based on many fewer attributes than the classification (Sokal 1974).

As the number of attributes used in a classification increases, the number of classes that are necessary to accomodate them also increases. A classification having a large number of classes may be unwieldy. However, some attributes may be correlated with a number of other attributes. The classifier who aims for a natural classification can minimize the number of classes needed by classifying on the basis of attributes that are correlated with as many other attributes as possible.

Classification systems used for mapping may be place-independent or place-specific (Davis and Henderson 1978). Place-independence requires that a site be identifiable only by characteristics that can be observed or measured on the site in question. For example, the system described by Kerr (1980) for classifying habitat for sedentary animals is place-independent; information about animals found in sampled areas is extrapolated to unsampled areas with similar habitat characteristics. But for mobile species, similar areas may have different values. The habitat value of an area is affected by the attributes of adjacent areas. Also, most large ungulates tend to acquire learned behaviour patterns which can cause them to bypass suitable ranges in favor of traditionally used ranges. For these reasons, a place-specific system is used for mobile animals (Kerr 1980).

Classification systems may be hierarchical, or they may operate at a single level. In hierarchical systems, each level is an aggregation of those and only those classes in the level immediately below it. Classes become more homogeneous at lower levels in the hierarchy; they also become more expensive to identify and map. Hierarchical classifications are often desired by managers, because they may be applied at different levels of management. At any level in the hierarchy, there is a tradeoff between cost and accuracy (Bailey et al. 1978, Davis and Henderson 1978).

Methods for constructing classification systems vary in their relative proportions of objectivity and subjectivity. According to Williams (1967), some persons have the ability to elucidate underlying patterns in complex systems without specifying the criteria by which choices are made. Highly subjective classifications depend greatly on the ability of the classifier to do this. The advent of computers, which require explicitly stated rules to produce a classification system, has led to attempts to make the process more objective (Sokal 1974). Classifications relying on numerical techniques are objective in the sense that the computer performs without bias. However, subjectivity enters the process at several points including selection of plots, selection of attributes, and assessment of the classification system generated by the computer. Williams (1967) argues that despite the value of numerical methods, professional judgment must continue to have a role in classification.

CLASSIFICATION SYSTEMS AND WILDLIFE HABITAT

A large number of systems for classifying land and land-based resources are presently in use in North America. A review of these systems is beyond the scope of this problem analysis. Rather, this discussion is limited to

classification systems that are related to wildlife habitat. Included are habitat assessment schemes (Habitat Evaluation Procedures), which generally utilize classification systems; information systems for storing and retrieving wildlife habitat information (RUN WILD, ECOSYM, The Blue Mountains Handbook, The western Washington - Oregon project), and efforts to incorporate wildlife data in ecological classification (Canadian Committee on Ecological Land Classification).

In response to legislative mandates in the United States, there has been a major effort in the last decade to develop methods for incorporating quantitative assessments of fish and wildlife habitat into decisions about natural resource management. The role of classification in the ecological assessment process has been described by Coulombe (1978). Its function is to organize information so that it can be taken in, processed, and results presented in a systematic way. It provides a framework for the other components of the assessment process.

A variety of methods exist for assessing the quality of terrestrial wildlife habitats. Some of these approaches have been discussed and evaluated by Asherin et al. (1979), Ellis et al. (1979), and Whelan et al. (1979). Habitat assessment methodologies typically address some of the same issues that must be addressed by the IWIFR program: the delineation of classification units, the selection of wildlife species for evaluation, the assessment of units in terms of their value to wildlife, and the need to predict future habitat values.

Habitat Evaluation Procedures

A prominent example of such a methodology is the Habitat Evaluation Procedures (HEP) of the United States Fish and Wildlife Service (1980a, 1980b), a set of methods for use in impact assessment and project planning.

The HEP methodology is used to document the quality and quantity of available habitat for selected wildlife species. It may be used to compare the relative value of different areas at the same time, or of the same area at different times.

The HEP methodology (USF & W 1980b) requires that vegetation cover types be delineated in the study area. HEP does not specify a particular classification system, but recommends that biologists select a regionally accepted classification system that is compatible with available mapping resources. Wildlife species to be used for evaluation are selected either for their public interest or economic value, or to provide a broad ecological perspective. The two approaches may result in completely different outcomes. Results may be extrapolated to the larger wildlife community only if evaluation species are carefully selected to represent the overall community structure. This is done through the identification of feeding and reproductive guilds (groups of species sharing similar habitat requirements) for each cover type, and the selection of appropriate species to represent them.

An area's value as wildlife habitat is quantified on the basis of a Habitat Suitability Index (HSI) and the total area of available habitat. The HSI is derived from an assessment of the ability of key habitat components to meet the requirements of the evaluation species. The same key components are used to compare existing habitat conditions and optimum habitat conditions for the species. The HSI expresses the relationship of existing conditions to optimum conditions, and ideally it has a proven, quantified relationship to habitat as described by carrying capacity.

Implementation of HSI ratings requires that an HSI model be developed or adopted from the literature. The model provides the rules by which an HSI is determined from key habitat components for a particular evaluation species at a particular location. If interspersion between cover types is important to the species, then the HSI model should account for it.

The same models that were used to determine baseline HSI values are used for future HSI values. Methods are described for assessing project impacts by quantifying habitat conditions for target years throughout a defined period of analysis. Predicting HSI values for future years requires an understanding of changes in the physical, vegetative, and chemical variables of each cover type (USF & W 1980b). Presumably, a separate model may be required for this.

RUN WILD

Classification systems, in themselves, provide limited information about the classification units, though classifiers may use available data to provide interpretations of units. For storing and retrieving data associated with classification units, an information system is needed. Several information systems have been developed that are associated with classification systems and that handle wildlife habitat information. RUN WILD (Patton 1978) is a storage and retrieval system for wildlife habitat information for the American Southwest. It is associated with the hierarchical vegetation classification system of Brown and Lowe (1974). For a given vegetation type, the system can provide a list of associated wildlife species; for a given wildife species, it can provide a list of associated vegetation types, together with information on activities (e.g. breeding, feeding) and season of use.

ECOSYM

ECOSYM (Henderson and Davis 1978) is a classification and information system for the management of all wildland resources, including wildlife. The classification framework is a set of hierarchical component classifications which include bedrock geology, regolith, topography, climate, soil, current vegetation and potential vegetation. The classification system developed for current vegetation is a synthesis of units from several sources; the classification system for potential vegetation is based largely on the habitat types

of Daubenmire (1973; Daubenmire and Daubenmire 1968). Henderson and Davis used a set of component classifications because they considered it more flexible than an integrated classification system; integrated systems were thought to be more appropriate for particular management applications than for general use. The ECOSYM information system is a set of rules for transforming the component classifications of an ecosystem into information that can be used by managers. The rules vary from simple associations to complex integrations which require external data inputs as well as the components.

The Blue Mountains Handbook

The handbook of Thomas (1979) for the Blue Mountains of eastern Oregon and Washington is essentially an information system for predicting the impact of forest management practices on wildlife. Thomas distinguishes between management for species richness and management for featured species, and treats the two production goals differently.

The information system presented for diverse species is best suited for use in broad-scale land-use planning (Thomas 1979). The 378 wildlife species occurring in the study area are grouped into 16 life forms -- species groups having similar habitat requirements for reproduction and feeding. Wildlife habitats are equated to plant communities and their successional stages, so that they can be more easily considered in timber management planning.

To identify plant communities, a classification system was needed. Level of detail was one of the major considerations in selecting a system. The potential natural vegetation system of Kuchler (1964), which is used by the Bureau of Land Management, was considered too broad (C. Maser, pers. comm.). The regional classification system of Hall (1973), which is used locally by the Forest Service, was not selected because its level of resolution was too detailed for available information on the relationships of wildlife to their

habitats. The starting point that was chosen was the classification of Garrison et al. (1977) of forest and range ecosystems of the United States. This classification, which is widely used by the United States Forest Service, identifies 34 ecosystems (soil-potential vegetation units) in the contiguous 48 states. Eleven of these ecosystems occur in the Blue Mountains. This classification system was modified by Thomas (1979) into units, referred to as plant communities, which better fitted the wildlife habitat conditions of the Blue Mountains.

The basis for modifying the units of Garrison et al. (1977) into units of significance to wildlife, was the concept that animals respond to vegetative structure, rather than to species composition (Thomas 1979, C. Maser pers. comm.). Structurally similar ecosystems were grouped, and ecosystems composed of structurally distinct communities were subdivided. In modifying the units, the team drew on a body of inventory data for the area which related trap results, and other indices of animal abundance, to the vegetation (C. Maser pers. comm.). Communities which are too small in areal extent to be recognized by Garrison et al. (1977), but which are important to wildlife - such as aspen stands and riparian areas - were distinguished.

These plant communities were then cross-referenced to those of Garrison et al. (1977), Hall (1973), and Kuchler (1964). By using a classification system which differed from that of any agency, but could be related to those of all agencies, Thomas (1979) made it easier for all agencies to use the information system provided in the handbook (C. Maser, pers comm.).

Thomas (1979) handled the problem of succession by distinguishing six broadly-defined successional stages: grass-forb, shrub-seedling, pole-sapling, young forest, mature forest, and old growth forest. In this system, management practices such as cutting, burning, planting, and grazing, may affect succession either by advancing it or retarding it. Thomas (1979)

acknowledged that the conditions produced by these activities differ somewhat from natural conditions, but accepted them as roughly equivalent because the structure of the altered forest is similar to natural conditions at various stages of succession.

As an example of an information system for featured species management, Thomas (1979) presented a system for predicting the effects of alternative timber management plans on deer and elk. For this purpose, the classification system used for diverse-species management was replaced by a classification system based on land-types. The 32 land-types defined for the Blue Mountains are combinations of land features and vegetation which are used to predict the way plant and animal populations will respond to timber harvest practices. They are defined by vegetation characteristics, soil features, topographic features, and some miscellaneous characteristics: size and general shape, slope position, adjacent vegetation, and available water. Land-types typically include two or more plant communities in a recurring pattern. An example of a land-type is a ridge which potentially supports a climax stand of grand fir on its north-facing slope, and an open Ponderosa pine stand or grasslands on the south-facing side. Such a land-type, which includes both cover and forage areas, has a characteristic value for deer and elk (C. Maser, pers. comm.).

In an appendix, land-types are related to the management units used by the National Forests. The proposed system for coordinating timber management with deer and elk management on land-types is through the relative proportions of cover areas and forage areas. Each land-type is characterized in terms of its potential forest cover, its optimum forest cover, and the amounts of cover needed to achieve various levels of deer and elk use. Remarks indicate land-types where thermal cover, hiding cover, or other habitat features are especially important. This information may be used by managers to predict the effects of alternative timber management plans on deer and elk.

The western Washington - Oregon project

A classification and information system for western Washington and Oregon, based on Thomas' model, is presently being developed under the direction of R. Brown, USDA Forest Service, Olympia. Ecologically, this area has more in common with Vancouver Island than do the Blue Mountains. The potential vegetation of the Blue Mountains is high in structural diversity; the area is a mosaic of closed forest, open forest, shrublands, grassland, and alpine meadows. Except for a few communities of limited areal extent, the potential vegetation of western Oregon, Washington, and Vancouver Island is closed forest. Brown (pers. comm.) found that at the level of differentiation used by Thomas (1979), 90% of his project area fell within two plant communities.

Using plant ecologists J. Franklin and F. Hall as resource persons, Brown's group developed a new classification system. The system was reviewed by wildlife biologists, who assessed the units in terms of their significance to animals. Structure was the most important factor, but species composition was also considered. This process resulted in the definition of three riparian and thirteen upland plant communities. Six successional stages which differ slightly in definition from those of Thomas, are used (R. Brown, pers. comm.).

The western Washington-Oregon program will include management for species diversity and featured species. Featured species or species groups to be included are spotted owl, bald eagle, deer and elk, and salmonids. The information system for deer and elk has not been completed, but will probably be based on plant communities rather than on land-types. Site classes (forest productivity classes) may be incorporated into the classification. The system for coordinating timber management with deer and elk management will probably be based on forage/cover ratios, like that of Thomas (1979). However, the concept of "survival cover" -- cover which is essential to support animals during periods of heavy snow -- will be included (R. Brown, pers. comm.).

Canadian Committee on Ecological Land Classification

The integration of wildlife data with ecological land classifications has been identified as an important need by the Canadian Committee on Ecological (Biophysical) Land Classification (Taylor 1980b). The recently established Wildlife Working Group of this Committee is working toward this goal. Progress up to 1979 was summarized at a workshop on the incorporation of wildlife information into ecological land surveys (Taylor 1980a).

The problem addressed in most of the workshop papers (Taylor 1980a) was that of relating data on wildlife abundance to the units established through ecological land classification. Success in relating wildlife data to ecological units varied, but there were several points on which participants agreed. Ecological classifications commonly ignore several factors which are important to wildlife: aspect, "patchiness" of vegetation, proximity of escape terrain (Taylor 1980b), snow depth (Prescott 1980, Taylor 1980b), details of the understory vegetation (Holroyd 1980, Prescott 1980), and actual rather than potential vegetation (Kerr 1980, Taylor 1980b). The units established by classifiers from other disciplines do not necessarily meet the needs of wildlife biologists (Holroyd 1980, Prescott 1980). The wildlife biologist should participate in the classification process from the beginning to ensure that factors important to wildlife are taken into consideration in setting up the classification (Stelfox 1980, Taylor 1980b).

Of the activities that have been discussed, the problems faced by the IWIFR program are most like those addressed by Thomas (1979) and Brown: the need for an information system, linked to a classification system, which can be used to predict the effects of timber management practices on wildlife. Like the agencies attempting to develop methods for habitat assessment, such as HEP, the IWIFR program must deal with the selection of a classification system, the selection of species for consideration, the assessment of units in

terms of their value to wildlife, and the need to predict future habitat values. The experience of those who have attempted to incorporate wildlife data into ecological classifications suggests that existing classification systems may require some modification in order to fully meet the needs of the IWIFR program.

III. INFORMATION NEEDS

Before any system could be evaluated, it was necessary to determine the information needs of forest wildlife researchers and managers relevant to the selection or development of a classification system. I reviewed the literature and interviewed members of the Technical Working Group (TWG) of the IWIFR program to find out what they wanted from a classification system. Two kinds of needs were expressed: general characteristics that were desired in a classification system and specific habitat attributes about which the group wanted information. Although the needs discussed below are those of the IWIFR program, many of them apply to wildlife research and management in general.

GENERAL INFORMATION NEEDS

Needs expressed by the Technical Working Group

Members of the TWG want a classification system, or systems, for the following broad purposes:

1. As a basis for research. There was general agreement that a classification system is needed for the intensive forestry/wildlife research that will be conducted in the IWIFR program. Specific objectives include selection of research sites and extrapolation of research results.
2. As a tool for habitat management. There was a strong demand for a classification system that could be used to apply current information and research results to management.
3. As a tool for watershed planning. Managers expressed the need for classification units that correspond to habitats selected by wildlife.
4. As a tool for broad resource planning. A few members of the TWG requested a classification of wildlife capability.

Flexibility was perceived as an important requirement of a classification system. The classification must be supported by a readily accessible data base. It was recognized that changes will occur in management objectives and understanding of species ecology, and it must be possible to return to the original data to make new interpretations. For data to be reanalyzed efficiently, they must be computer-retrievable.

The group expressed a strong desire for a mapping system as well as a classification system. Maps are required for the selection of appropriate research sites. The value of an area as wildlife habitat often depends on characteristics that are most easily interpreted from maps, such as size, shape, and the attributes of adjacent units.

Members of the TWG want a classification and mapping system primarily for use on a site-specific basis or for watershed planning. They want a detailed classification system which could be applied anywhere on the island, and which could form the basis for large-scale maps. Initially, these maps would be prepared for selected watersheds, such as research areas or areas of special management concern. Later, their use might be extended.

The desired scale for these maps was 1:10,000 or 1:15,840. 1:20,000 was considered marginal; several persons remarked that too much detail was lost at that scale. 1:50,000 was considered unacceptable for detailed project areas.

The mapping system must be able to deal with internal complexity -- inclusions, patchiness, and special features such as rock bluffs or wetlands -- in a way that is relevant to wildlife.

Some persons suggested that small-scale as well as large-scale classifications and maps were needed. Small-scale maps would be used for

regional resource planning, and could form the basis for capability maps. They could be used in the initial stages of site selecion for research activities. 1:250,000 was the scale suggested for these purposes.

The TWG agreed that the classification and mapping system must deal with existing vegetation, though climax vegetation units may be necessary as a basis for interpretation and for describing succession. There was a clear demand from the group that successional stages be addressed in detail within mature as well as younger stands. Successional stages vary greatly in the resources they provide to wildlife. To predict the effects of a management scenario on the habitat values of a watershed, it is necessary to know the status of each unit within the watershed, and how it will change over time. A classification system must provide a framework for describing the floristic and structural characteristics of seral stages, and their rates of change.

There was no consensus within the group on the degree to which the habitat requirements of non-game species should be considered in evaluating classification systems. One member, as well as several individuals outside the TWG, made a strong case for a classification system that would allow the prediction of the effects of forest management activities on all species. In general, the group recognized that the management of non-game species would probably become more important in the future, as public demand for it increased. Most members would like to see a classification system that is appropriate for deer and elk management, and for the management of other species if that is possible. The concern was expressed that the task would become exponentially more difficult as additional species were taken into consideration, and that an attempt to address the needs of all species would compromise the effectiveness of the system in dealing with deer and elk.

Some members emphasized the importance of classification units that are readily identifiable on the ground. Preferably, they should be recognizable

at any time of year, and by persons without a great deal of specialized training.

Discussion

The major research objective of the IWIFR program is to provide information needed for effective integration of forest and wildlife management on Vancouver Island. The research will focus on relationships between intensive forest management practices and wildlife. Because of the nature of the research, the first two purposes given by TWG members -- a classification as a basis for research, and a classification as a tool for habitat management -- are strongly linked. A classification system that will meet these needs must provide units that are more or less homogeneous in their response to forest management treatments. As response to forest management treatments involves a variety of interactions within a complex system, a natural classification system -- one which is suitable for a large number of purposes -- is needed.

Natural classification systems are commonly used as a basis for stratification in research. If a single classification system must be used in a multi-faceted research program, then a natural classification system is the best choice. However, not all attributes of the landscape correspond well to ecological units. In a particular research project, the specific population (or attribute) under investigation may not be correlated with the units of the natural classification system. In this case, the researcher may need to define his own strata according to the distribution of the population of interest, i.e. to develop his own technical classification system. It is up to the researcher to determine whether or not an existing natural classification system provides suitable strata for a particular research topic. However, research results should be related to a natural classification system, if possible, to facilitate their use in management.

The classification systems implicit in the third and fourth purposes (p. 17) differ from the classification system required for purposes 1 and 2. Units that respond uniformly to management practices do not necessarily correspond to habitats selected by wildlife. Large mobile species often select home ranges in which different habitat requirements are met in different areas. For example, a deer winter range unit might include more than one ecological unit, as well as a special feature such as rock bluffs. In parts of the Koprino watershed, heaviest deer use was found along the boundaries between ecological units (R. Davies, pers. comm.). The importance of edges to sedentary as well as mobile wildlife species is well documented in the literature (e.g. Thomas 1979). At mapping scales of 1:50,000 or smaller, these factors are relatively unimportant (D. Demarchi, pers. comm.). But at the level of resolution required by the IWIFR -- a mapping scale of 1:10,000 to 1:20,000 -- they are likely to significantly affect the relationship between ecological units and wildlife habitat.

Although ecological units may not correspond well to habitats selected by wildlife, a wildlife biologist should be able to make interpretations about their value as habitat. The ecological classification should be a good basis for a more technical classification of wildlife habitat. For example, ecological units might be grouped into habitat complexes, such as the land-types of Thomas (1979). To be suitable for this purpose, the classification system should provide units that are more or less homogeneous with respect to as many as possible of the attributes that are important to wildlife. Attributes important to wildlife should be included in the characterization of the units.

In a wildlife capability classification, areas are grouped according to their ability to support given numbers of animals. This may mean that areas that are otherwise heterogeneous are included in the same classes; e.g., a

steep, south-facing winter range and a valley bottom winter range may be similar in their ability to support an ungulate species, but otherwise very different. In some capability classifications, classes are further differentiated according to environmental characteristics, such as landform and climate. Even where this is done, subdivisions of wildlife capability classes are not necessarily intended to be homogeneous with respect to their responses to management.

A capability classification is a technical classificaion which, like a wildlife habitat classification, may be based on a natural ecological classification. To be a good basis for a wildlife capability classification, the natural classification must provide units for which wildlife values can be interpreted.

The criterion of flexibility is an important one. It is clearly undesirable to base a research and management program on a classification system which becomes obsolete as new information is acquired or management objectives change. By definition, a natural classification, which is suitable for many purposes, is required. Because they are based on fewer rules and assumptions, classifications having a low degree of information synthesis tend to be more stable than integrated or interpretive classifications. It is often said that separate component classifications permit greater flexibility of use, and more opportunity for modification and reinterpretation (Davis and Henderson 1978, Stelfox 1980). According to Bailey et al. (1978), classifications that provide precise criteria and the opportunity for revision stand the test of time. Because revision is difficult when the original criteria are not specified, classifications based on loosely specified criteria become obsolete.

The need for a classification system that deals with existing vegetation is often expressed by wildlife biologists (Kerr 1978, Taylor 1980b). The

IWIFR program requires not only static maps showing existing vegetation, but a framework for predicting changes in vegetation over time. Members of the TWG envision a framework in which, for each ecological unit, successional stages are identified and described in terms of their structural and floristic attributes. The information system associated with such a framework would provide information on rates of change and on the effects of management practices on the successional patterns.

The development of such a framework would require a great deal of information that is not presently available. Secondary succession on Vancouver Island has not been comprehensively described (J.P. Kimmins, pers. comm.), though a few studies have been completed (Mueller-Dombois 1959, Houseknecht 1976) and others are in progress. Several factors create problems in studies of secondary succession.. It is often difficult to identify the potential climax vegetation of a site that is presently in a seral state. In the early years after logging, ubiquitous pioneers and false indicators may mask differences among ecological units. Furthermore, the ecological unit is only one of the factors determining patterns of secondary succession. On environmentally extreme sites, successional patterns tend to be distinct, but on sites with moderate moisture and nutrient regimes, the pattern of secondary succession depends more on chance and on the nature of the disturbance than on the ecological unit (J.P. Kimmins, pers. comm.). Intensity of burning and availability of seed sources are examples of factors that can cause different successional patterns on ecologically similar sites. A model of succession that could be used to predict vegetation responses to forest management would require considerable research.

Thomas (1979) avoided this problem by dealing with succession in a simplified way: six successional stages were defined on the basis of structure, and were applied to all forested plant communities. Members of the

TWG feel that they require information about species composition as well as structure of successional stages. Floristic differences in structurally identical seral communities can produce marked differences in value as ungulate habitat. In the Nimpkish Valley of northern Vancouver Island, for example, some recent clearcuts are dominated by fireweed (Epilobium angustifolium), a valuable spring and summer forage item for black-tailed deer. Other clearcuts support a community dominated by bracken (Pteridium aquilinum), which is not used by local deer populations. A structural classification would not distinguish these two communities.

In accord with the terms of reference for this problem analysis, major consideration is given here to the application of classification systems to deer and elk management. It has already been established that the classification system selected for deer and elk management must be flexible and must be suitable for many purposes. It is unlikely that the selection of any one classification system would prejudice the development of a research and management program for all species. However, to be useful for diverse species management, ecological units must be characterized by many more attributes than those that are significant to deer and elk. In the following section, the habitat characteristics thought to be important to deer and elk are discussed. If the IWIFR program is to deal with research and management for other species, then the habitat characteristics important to other species should be identified and included in the characterization of ecological units.

SPECIFIC INFORMATION NEEDS

To make inferences about the value of any particular ecological unit to deer and elk, wildlife biologists need specific information about the physical and biological attributes of the unit. These inferences may be used to predict the effects of forest management activities on deer and elk, or to develop interpretive classifications and maps.

Members of the TWG were asked to describe the information they need in order to make inferences about the value of a site as elk or deer habitat. These information requirements represent a conceptual model of the biologists' understanding of deer and elk habitat. The concept of habitat for a given species may be separated into a set of life requisites, referred to by Coulombe (1978) as habitat components. Table 1 summarizes information needs for the evaluation of deer and elk habitat, in the form of broad questions that are related to habitat components. Information provided by the TWG was supplemented by a list of habitat requirements for black-tailed deer developed by the Vancouver Island Interagency Committee (minutes of meeting, May 23, 1980), by Scoullar (1981), and by interviews with other biologists.

The items in Table 1 are listed without consideration to how they might be quantified. In practice, the wildife biologist rarely has quantitative data on any of those items as they are presented. The biologist instead bases his interpretations on a set of objective, multipurpose descriptors or measurements often referred to as data elements (Coulombe 1978). These data elements are surrogates or indices that are more easily quantified than the ideal information requirements listed in Table 1. Table 2 lists a set of data elements proposed by members of the TWG and other biologists as a basis for interpreting habitat components for deer and elk. Only data elements which might reasonably be collected at an inventory level are included. Data elements related to forage quality are omitted, as they require an intensity of study that is not feasible at that level.

Table 2 does not specify methods or units of measure for the data elements. There was considerable confusion about the importance of some items, and about how others might best be quantified. The following problem areas were noted:

TABLE 1. Information requirements for the evaluation of habitat components for deer and elk.[1]

FOOD

Quantity

- available biomass of herbs eaten by deer
- available biomass of herbs eaten by elk
- available biomass of shrubs and conifer regeneration eaten by deer[2]
- available biomass of shrubs and conifer regeneration eaten by elk[2]
- litterfall, during winter, of lichens eaten by deer
- availability of these forage classes at various snow depths

Quality

- nutrient composition (N, Ca, P) of available deer forage
- nutrient composition (N, Ca, P) of available elk forage
- energy value of available deer forage
- energy value of available elk forage

SHELTER COVER

- interception of snow by the canopy
- effect of vegetation on heat exchange by radiation
- effect of topography on heat exchange by radiation
- effect of vegetation on heat loss by convection
- effect of topography on heat loss by convection

TABLE 1 continued.....

HIDING AND ESCAPE COVER

- ability of the vegetation to hide, or offer security to, a deer
- ability of the vegetation to hide, or offer security to, an elk
- ability of the topography to hide, or offer security to, a deer
- ability of the topography to hide, or offer security to, an elk

REPRODUCTIVE COVER

- same factors as required for hiding and escape cover
- distance to water

OTHER FACTORS (These items affect the animals' need for or ability to utilize the habitat components)

Local climate

- snowfall and snowmelt
- incident solar radiation

Ease of movement

- amount of debris that would impede deer movement
- amount of debris that would impede elk movement
- topographic features that would impede deer movement
- topographic features that would impede elk movement

Spatial distribution of habitat components

- attributes of adjacent areas
- amount and arrangement of edge
- fine-grained patchiness of vegetation and topography

1/ Based on information provided by TWG members and other biologists.

2/ Includes current annual growth and older material in some species.

TABLE 2. Data elements for the evaluation of habitat components for deer and elk.

DATA ELEMENT	INTERPRETATION[1]
Physical features	
Slope	LC
Elevation	LC
Aspect	LC
Relief	SC,HC-RC,EM
Rock outcrops	LC,HC-RC,SC
Distance to water	RC
Overstory	
Tree height	SC
Crown closure	SC
Stand age	SC
Tree species	SC
Patchiness of canopy	SC,SD
Stems/ha	SC
Average basal area/stem	SC
Crown length	SC
Understory	
Biomass or surrogate (e.g. % cover)	
by layer	HC-RC,SC
by species	FA
by species and layer	FA
Distribution	
by species and layer	FA,SD
Visual density	
by layer	HC-RC
Crown length of forage species	FA

Stem density of forage shrubs	FA, predicting response to management practices
Browse utilization by species	
% of plants showing signs of browsing	assessing current use
average % of each plant browsed	assessing current use
distribution of browsing	assessing current use

Other

Abundance of arboreal forage lichens	FA
Obstructive debris	EM
Interspersion with other units	SD

1/

FA	Food availability
SC	Shelter cover
HC	Hiding and escape cover
RC	Reproductive cover
LC	Local climate
EM	Ease of movement
SD	Spatial distribution of habitat components

- The profusion of data elements concerning the overstory reflects uncertainty about which canopy characteristics are associated with interception of snow and radiation.

- The importance of the understory in thermoregulation is unclear.

- Percent cover is a widely-used surrogate for forage availability, but it has obvious deficiencies, and some biologists suggested searching for better indices to forage availability.

- Some persons thought information on vertical distribution of shrubs should be more detailed than is usual in ecological descriptions. Biologists agreed that at least shrubs of less than 1 m should be distinguished from shrubs of 1-2 m. Some suggested finer distinctions, but others thought that too many layers would be difficult to handle in the field. Information on vertical distribution of shrubs is important for assessing hiding cover, and for predicting forage availability at various snow depths.

- Abundance of arboreal forage lichens is difficult to estimate consistently and accurately.

- There was no agreement on methods for quantifying visual density or obstructive debris, although these variables do not seem intrinsically difficult to measure at an inventory level.

- Interspersion is probably better judged from maps or air photographs than on the ground.

There is clearly a need to review methods for quantifying these data elements. A few of these methodological problems may require original research, but most have been dealt with by others.

Wildlife biologists need information about habitat components to assess the wildlife value of ecological units. The data elements in Table 2 need refinement, but represent the kind of information required to make these assessments for deer and elk. Many of these data elements, such as "understory biomass", are likely to be related to ecological units. Others, such as "distance to water" and "interspersion with other units", may be treated as attributes of ecological units, or may be interpretable from maps. Some data elements, such as "obstructive debris", may prove unrelated to ecological units. Wildlife biologists need ecological units that are correlated to as many data elements as possible, and they need descriptions of ecological units that include this information.

IV. CLASSIFICATION SYSTEMS USED ON VANCOUVER ISLAND

On Vancouver Island, a number of classification projects are underway, or have recently been completed. It is not possible to describe all these activities in detail here. The following factors were considered in selecting the projects to be discussed in detail:

1. Major classification programs of provincial government agencies should be included.
2. Classification programs to be discussed in detail should represent diverse approaches.
3. Classification systems that focus on wildlife or vegetation are most relevant to the objectives of the IWIFR program.
4. Detailed information about one of the major classification programs of a private company is unavailable, as the system is still being developed.

The programs selected for detailed treatment were the ecosystem classification program of the Ministry of Forests, the biophysical classification program of the Ministry of Environment, and the Moon/Selby system developed by individuals within Agriculture Canada. Other classification activities are described briefly. Descriptions are up-to-date as of spring, 1981.

The descriptions that follow include a number of specific examples of the products of ecological classifications. These were included because it is important to examine what classifiers actually produce, as well as what they say. However, the reader should bear in mind that classifiers can and do vary their products according to the objectives of a particular project.

THE ECOSYSTEM CLASSIFICATION PROGRAM OF THE MINISTRY OF FORESTS (VANCOUVER FOREST REGION)

Although the Ministry of Forests (MOF) has been involved in some site classification work since the early forties (Spilsbury and Smith 1947), developments in the seventies stimulated a much greater interest in ecological classification. Expanded tree planting programs focussed attention on the need for ecological information to prescribe site preparation, select tree species, and define seed collection zones. Increasing emphasis on resource planning created a demand for an ecological framework. There was a greater awareness of the need for ecological information as a basis for management prescriptions to reduce environmental damage during logging. Concurrently, more information about soils and climate in the province became available, making a better classification system possible (Schmidt 1977).

The Research Branch of the Ministry of Forests initiated an ecological classification program in 1975. Some of the pioneering work in this province-wide program has been done in the Vancouver Forest Region. Reports arising from the regional program include Klinka (1977), Klinka et al.(1979), Klinka et al.(1980a), Klinka et al.(1980b), Klinka and Carter (1980), and Klinka et al.(1981). The following description is based primarily on the classification and mapping of biogeoclimatic units on central Vancouver Island (Klinka et al. 1979), the detailed classification and mapping of the Koprino watershed (Klinka et al. 1980b), and on interviews with K. Klinka and F. Nuszdorfer. Some concepts and procedures differ from one MOF region to another. As this description is based on work carried out in the Vancouver Forest Region, it does not necessarily apply to MOF activities elsewhere in the province.

Objectives

The overall purpose of the ecosystem classification of the MOF is "to organize our knowledge so that properties of ecosystems and their

relationships may be better understood and more effectively utilized for resource management" (Klinka et al. 1979). Two objectives are implicit in this statement: a classification which aims to organize knowledge, and a classification to be applied as a tool for resource management. To meet the first objective, a "natural taxonomic classification" has been applied to show relationships among the most common and important properties of ecosystems. Anticipated benefits of the classification include the following: By defining and naming units, a classification facilitates communication. It provides a context in which to gather new information; i.e., a framework for stratification for research, and a basis for comparative studies of ecosystems and their components. It provides predictive power; information about an ecosystem in one locality may be extrapolated to similar ecosystems in areas that have not been studied in detail (Klinka et al. 1979).

The second objective is to develop practical applications for the management of forest resources. The classification system of the MOF aims to serve as many facets of forest management as possible, including wildlife management (Annas and Coupe 1979). For specific management purposes, the natural classification may be simplified by grouping ecosystem units into treatment units. The result is an interpretive, or technical classification.

The MOF has adopted two basic approaches to presenting ecological information to meet these objectives (Annas 1977). One is to provide detailed classification and maps at a scale suitable for subunit planning, 1:20,000 or larger. The Koprino study (Klinka et al. 1980b) is an example of such an undertaking. Because of the high cost, this scale of mapping is suitable only for small areas of special significance (Annas 1977). The second approach is to provide field personnel with the necessary information to recognize ecosystem units on the ground. As ecosystem units can be identified most easily when the biogeoclimatic subzone is known, a province-wide program of

biogeoclimatic mapping at 1:500,000 has been undertaken (Annas 1977). Various tools, such as edaphic grids and topographic diagrams, are being developed to facilitate identification of ecosystematic units within biogeoclimatic subzones.

Philosophy

The classification system of the MOF is based on the work of V.J. Krajina and his students at the University of British Columbia. The objects of classification are ecosystems (biogeocoenoses); i.e., interacting complexes of living organisms and the environment immediately affecting them. The model of ecosystem function is that of Major (1951): vegetation and soils are products of climate, parent material, topography, organisms, and time. Plants and soil, considered simultaneously, are thought to integrate and reflect ecosystem functioning, and are accepted as the most suitable components of ecosystems on which to base an ecological classification (Annas and Coupe 1979, Klinka et al. 1979).

The ecological classification system of the MOF may be conceptualized as having two levels: the biogeocoenotic level and the biogeoclimatic level (Annas and Coupe 1979, Klinka et al. 1979). The biogeocoenotic level deals with the classification of individual ecosystems, whereas the biogeoclimatic level deals with the distribution of ecosystems in relation to the regional climate (Annas and Coupe 1979). Within each level, a number of hierarchical categories have been defined.

The link between the biogeoclimatic level and the biogeocoenotic level is the concept of the zonal ecosystem. A zonal ecosystem is intermediate with respect to moisture and nutrient regimes. The influence of regional climate is expressed more strongly in it than in ecosystems that are influenced by

extremes of local physiography, parent material texture, or parent material chemistry. Zonal ecosystems typically develop on moderately deep loams on the upper to middle parts of gentle slopes, or on the upper topographic positions of flat watershed divides. The climax vegetation that develops in zonal ecosystems best reflects the potential of the regional climate, and is termed a climatic climax. Ecosystems that are wetter, drier, or richer or poorer in nutrients than zonal ecosystems reach edaphic climaxes. Each biogeoclimatic unit in the MOF classification scheme is characterized by a distinctive climatic climax zonal ecosystem, and a distinctive pattern of edaphic climax ecosystems (Klinka et al. 1979).

The regional climate is best expressed in zonal ecosystems where soils have matured for several thousand years, and the vegetation has been undisturbed for several hundred years. Because of the central role of the climatic climax zonal ecosystem in the definition of biogeoclimatic units, classifications based on Krajina's approach have emphasized climax vegetation. However, the MOF currently uses this approach to study non-climax stands as well.

Stratification and sampling

The object of stratification is to place sample plots within all recognizable ecosystems in the study area. Existing maps and ecological studies are used to ensure that all biogeoclimatic units are represented. Within biogeoclimatic units, sampling is stratified according to moisture and nutrient regime; an edaphic grid (Fig. 1) is used as an aid to stratification. The researcher typically aims for about six replications for each stratum. Intensity of sampling varies according to the areal extent of the stratum, and its importance for forestry. Sampling intensity also depends on the nature and scale of the project. The biogeoclimatic classification and

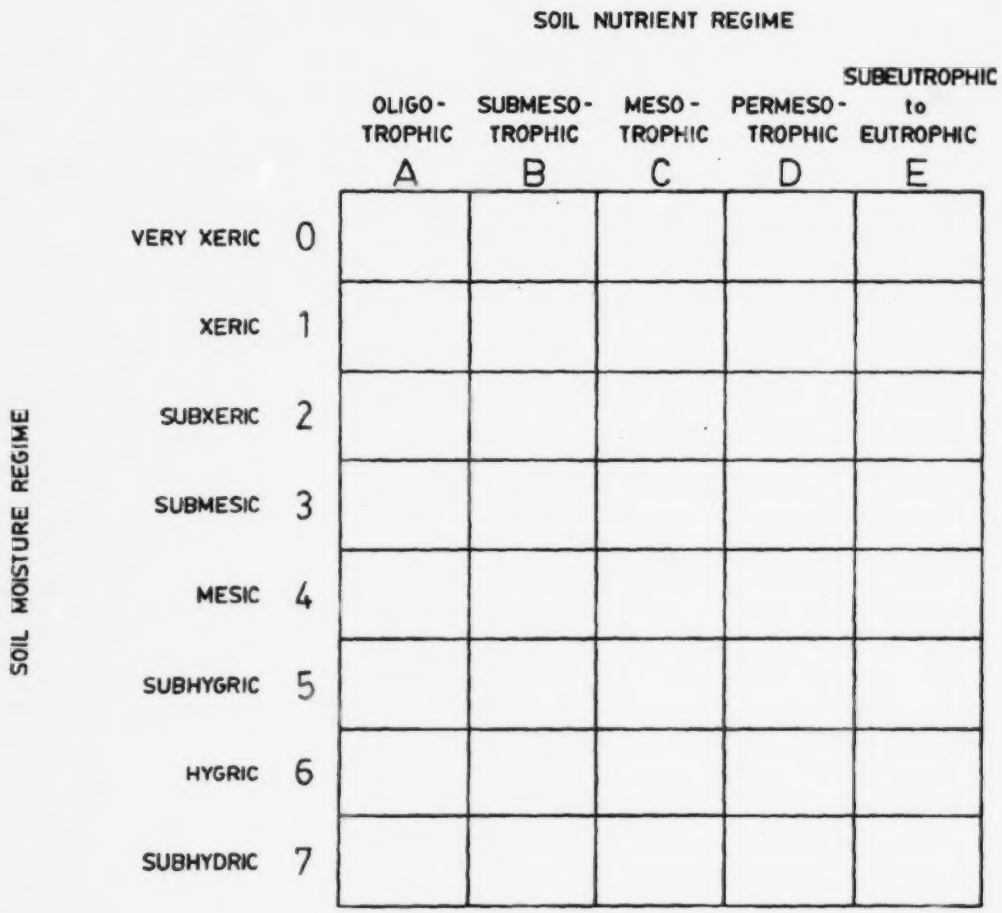

Fig. 1. Edaphic grid of soil moisture and nutrient regimes (Klinka et al. 1979:10).

mapping of central Vancouver Island was based on approximately 300 original plots, and 700 from previous studies - roughly 1 plot per 20 km^2. The biogeocoenotic classification of the Koprino watershed, an area of approximately 6000 ha, was based on 51 plots.

The MOF uses a selective approach to sampling. Sample stands are as uniform as possible with respect to vegetation and soils; heterogeneous, transitional, or disturbed sites are avoided. Except for special-purpose studies, such as one currently underway in the Sayward Forest, mature or near-mature stands (80+ years) are selected for sampling. Plot locations are chosen to represent particular combinations of soil moisture and nutrient regimes. Slope position, seepage, soil texture, base status of parent materials, plant indicators and tree growth are used as clues to moisture and nutrient regimes. The professional judgment of the experienced fieldworker in selecting representative sites is an important part of the methodology of this approach.

Plot size is approximately 500 m^2; plot shape is variable but is usually 25 x 25 m or 20 x 25 m. Standard data sheets are used to record site, vegetation, soil and mensuration data (Appendix 1), according to procedures of Walmsley et al. (1980) and Klinka et al. (1981b). The Domin-Krajina species significance scale (Kojima and Krajina 1975), based on percent cover, and vigor ratings are used to quantify vegetation abundance. Utilization of browse is quantified in two ways. For each species, percent of plants browsed and average percent utilized on browsed plants, are recorded in five classes: 1-10%, 11-25%, 26-50%, 51-75% and 76-100%.

Dominant epiphyte species are quantified by estimating the percent of available area in the canopy that is covered, using the same five classes. In some project areas, ungulate pellet groups are counted along belt transects around the perimeter of plots.

Analysis

The analytical procedures used by the MOF integrate vegetation and soil data. First, field and laboratory data are analyzed. Second, data are studied to elucidate environment-vegetation relationships. Finally, data are synthesized and plots classified.

This procedure begins with the coding of all vegetation data, selected forest stand data, and selected soil and environment data, for use in the computer program of Klinka and Phelps (n.d.). This program is a tool for the manipulation and presentation of vegetation and environment data. It does not perform any classification, but facilitates the sorting of data by the classifier. It was developed to aid in the classification of vegetation by tabular comparison, in the manner of Braun-Blanquet (Mueller-Dombois and Ellenberg 1974; 177-210). The program produces three types of tables: environment, vegetation, and vegetation summary. Environment and vegetation tables summarize environment and vegetation data according to the units differentiated by the classifier. The summary vegetation table gives species presence (frequency of occurrence) and mean species significance for all plant species in all differentiated units (Klinka and Phelps n.d.).

The object of the analysis is to group plots that are similar. The approach of the MOF is first to group plots by tentative biogeoclimatic unit and by moisture/nutrient regime. The vegetation tables, which list species by strata in order of presence and species significance for each tentative grouping, facilitate refinement of these groupings. Plots or groups of plots may be separated or moved to another group if they are floristically different. Groups that are similar in moisture/nutrient regime (i.e., occupy adjacent cells of the edaphic grid) are experimentally merged. Through this process of experimental grouping and refinement of groups, the biogeocoenotic (ecosystem) associations are established.

Biogeocoenotic associations, the basic units of ecosystem classification, are defined by their characteristic combinations of species, and their soil moisture and nutrient regimes; they are considered to be broadly homogeneous in successional sequence. Biogeocoenotic associations are then subdivided into biogeocoenotic types, primarily on the basis of edaphic factors, such as humus form, parent material, and horizon sequence. Factors that appear to vary together with other parameters, or that have potential significance in management, are preferred as the basis for differentiating types.

Biogeocoenotic associations are also grouped into higher units, such as plant alliances and plant orders, according to similarities in species composition. As many higher-level taxa have already been established by other workers, associations may often be fitted into existing alliances and orders. Biogeocoenotic orders, associations, and types are used in the definition of biogeoclimatic zones, subzones, and variants. Each biogeoclimatic unit is defined by a particular biogeocoenotic unit as its zonal ecosystem, and also by a set of climatic characteristics.

Mathematical treatment of vegetation data has not been employed in any studies completed so far by the MOF. However, the application of ordination and other numerical techniques as auxiliary methods has been initiated. For climate, stepwise discriminant analysis has been used to identify the variables that best distinguished biogeoclimatic units (Klinka et al. 1979).

Classification Units

Biogeoclimatic and biogeocoenotic units reported by the MOF staff in their work on Vancouver Island are summarized in Table 3.

TABLE 3. Biogeoclimatic and biogeocoenotic units of the MOF

BIOGEOCLIMATIC UNITS (Klinka et al. 1979)

Biogeoclimatic zone -- A geographical area predominantly controlled the by same macroclimate and characterized by the same zonal soil, vegetation, and animal community (Krajina 1965). Biogeoclimatic zones are defined by broad climatic variables and by zonal ecosystems classified as plant orders. Also described by a characteristic combination of species and a pattern of plant orders occurring throughout the zone.

Biogeoclimatic subzone -- Subdivision of a zone, defined by more specific climatic features and by zonal ecosystems at the biogeocoenotic association level. Also described by a characteristic combination of species and a pattern of associations occurring throughout the subzone.

Biogeoclimatic variant -- Subdivision of a subzone, defined by a further differentiation of climate and by zonal ecosystems at the biogeocoenotic type level. Also described by a characteristic combination of species and a pattern of biogeocoenotic tyes occurring throughout the variant.

Biogeoclimatic phase -- A geographical area having a local climate that differs from the regional climate because of local relief. Not used in biogeoclimatic taxonomy, but useful for explaining atypical ecosystems.

BIOGEOCOENOTIC UNITS (Klinka et al. 1979, 1980b)

Plant order -- A grouping of biogeocoenotic associations based on floristic similarities and related in successional trends, broad environment-vegetation relationships, and prevailing pedogenic processes.

Plant alliance -- A grouping of biogeocoenotic associations based on floristic similarities, below the level of the plant order.

Biogeocoenotic association -- The basic unit of ecosystem classification; the smallest homogeneous unit derived from sample plots that have similar vegetation structure and occur repeatedly on similar habitats. It is defined by a characteristic combination of species and soil moisture/nutrient regime.

Biogeocoenotic type -- A subdivision of a biogeocoenotic association, characterized mainly by edaphic features, and also by minor floristic features.

Biogeocoenotic variant -- A successional stage of a biogeocoenotic type, characterized (in forest stands) by the age, density, and species composition of trees.

To date, four biogeoclimatic zones, seven biogeoclimatic subzones, and eleven biogeoclimatic variants have been described for Vancouver Island, based on studies of the south and central parts of the island (Klinka et al. 1979). An additional subzone, with two variants, occurring on the northern part of the island has been tentatively identified (Klinka et al. 1980b). In the detailed study of the Koprino watershed, nine plant alliances, eleven biogeocoenotic associations, and 26 biogeocoenotic types were recognized. Studies of northern and western Vancouver Island, the Campbell River area, and the Cowichan Lake area are in progress.

Descriptions of the biogeoclimatic units occurring on central Vancouver Island were provided by Klinka et al. (1979). Descriptions of zones typically included their geographic distribution, the composition and structure of the tree canopy, and a brief description of the zonal ecosystem. Characteristic soil-forming processes, the soil great group, plant order, and humus form of zonal ecosystems were identified. General recommendations were made for land use, conservation of soil nutrients, tree species for reforestation, prescribed burning, and silvicultural system. Subzones of the zone, and the climatic features that differentiate them, were identified. Descriptions of subzones typically included geographic distribution, the composition and structure of the tree canopy, and the biogeocoenotic association that represents zonal ecosystems. The climatic features that differentiate variants of the subzone were identified. Descriptions of variants were similar to those of subzones: geographic distribution, characteristics of the tree canopy, and the biogeocoenotic type representing zonal ecosystems were given. In a few cases, presence of biogeoclimatic phases was mentioned, and management recommendations for the variant were made.

For all biogeoclimatic units described in the report, the characteristic combinations of species, names of zonal ecosystems, and means and standard deviations of climatic variables were presented in tables.

As an aid to understanding the geographic and topographic distribution of biogeoclimatic units, a schematic diagram was presented on the Nootka-Nanaimo mapsheet included with the report. Zonal ecosystems of biogeoclimatic variants were arranged along an east-west cross-section of Vancouver Island and the adjacent mainland. Soil profiles and forest productivity associated with zonal ecosystems were also represented.

Descriptions of biogeocoenotic associations occurring in the Koprino watershed were given by Klinka et al. (1980b;)(Fig. 2). Descriptions included size of unit and frequency of occurrence; topographic position; elevation, slope, and aspect; soil moisture and nutrient regimes; soil great group, order, subgroup, and phase; humus form; and several other soil parameters. Average cover on the ground of humus, mineral soil, decaying wood, and rocks and stones; and average cover in the tree, shrub, herb, and moss layers were given. The characteristic combination of species was listed. Comments typically included windthrow frequency, soil development processes, tree growth class, and a description of vegetation structure. Productivity and limitations for forestry were rated, and importance to wildlife mentioned. A schematic diagram of the association showed its characteristic vegetation structure and shape of local relief.

In addition to descriptions of individual units, several presentation formats were used to show relationships among biogeocoenotic associations. A schematic diagram of the sequence of biogeoclimatic associations in relation to topography was given for each of the two biogeoclimatic variants present in the watershed (Fig. 3). The relationships of biogeoclimatic associations to soil moisture and nutrient regimes in each variant were displayed on edaphic grids (Fig. 4). The edaphic grid, a matrix of eight soil moisture classes and five soil nutrient classes, is a presentation device frequently used by the MOF. In the regional species selection guide (Klinka 1977), edaphic grids

Biogeocoenotic unit: Salal - Alaskan Blueberry & Red Huckleberry - C - Hw Association

Biogeoclimatic unit: Wetter Maritime Northern CWH Subzone

Occurrence (size): common [small (<5 ha) areas]

Location: submontane (≤ 600 m) variant

Position on slope and relief shape: hilltops and adjacent convex slopes

Slope gradient (%): 0-70
Aspect: variable

Bedrock: conglomerate

Parent materials: organic or morainal

Soil moisture regime: 1-2
Soil nutrient regime: B-C
Texture (family particle-size class): organic; sandy loam (sandy)

Coarse fragments(%): 23

Soil: Typic Folisol, Podzol, lithic phase, or Orthic Ferro-Humic Podzol, lithic phase

*Humus form: Friable, Mycelial H-Mor pH: 3.8 C/N: 52
Rooting depth (cm): 39 Seepage water depth (cm): absent
Thickness of humus form (cm): 22 Thickness of mineral soil (cm): 18
Comments: acid soils with roots concentrated in humus; decomposition, humification, and mineralization of organic materials are slow

Ω Ground coverage (%) H: 56 MS: 0 DW: 37 R&S: 3
Strata coverage (%) A: 55 B: 86 C: 11 D: 61
Characteristic combination of species:
(Taxus brevifolia), (Thuja plicata), Tsuga heterophylla, (Gaultheria shallon), (Vaccinium parvifolium), (Hylocomium splendens)

Comments: open, old growth western hemlock and western redcedar stands; tree growth class: Hw 6, C 6, and Ba 7 **; common mistletoe infection on western hemlock; high and continuous coverage of mainly salal and red huckleberry in the shrub layer

Evaluation & interpretation: low productivity ecosystems with intrinsic limitations for forestry; winter wildlife range

---

* after Bernier (1968)

Ω abbreviations: H = humus, MS = mineral soil, DW = decaying wood, R&S = rocks and stones

** growth classes are based on the range of site indices presented in Appendix VII where abbreviations are also explained

Fig. 2. Sample description of biogeocoenotic association (Klinka et al. 1980b:61).

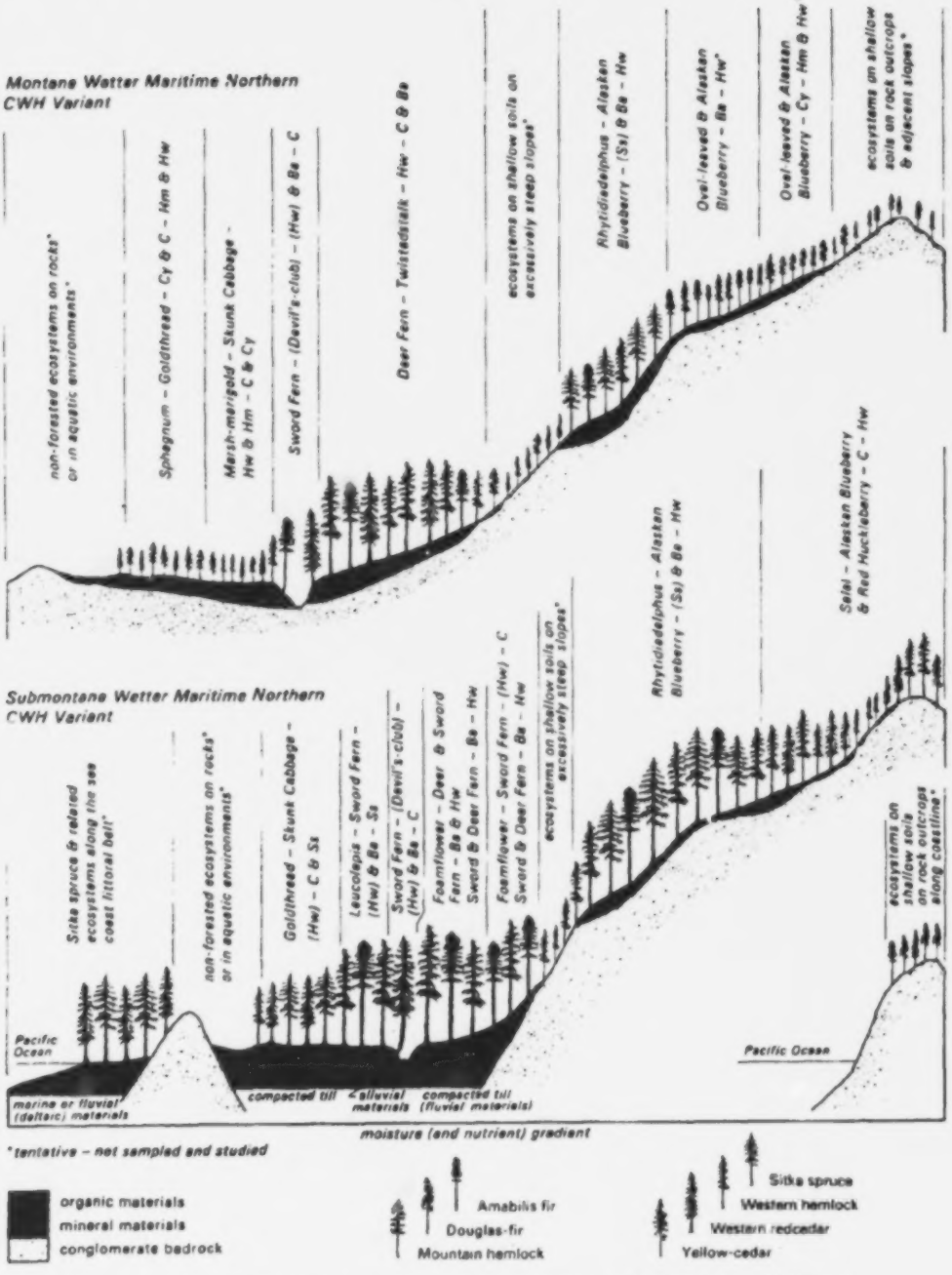
Montane Wetter Maritime Northern CWH Variant
non-forested ecosystems on rocks* or in aquatic environments*
Sphagnum - Goldthread - Cy & C - Hm & Hw
Marsh-marigold - Skunk Cabbage - Hw & Hm - C & Cy
Sword Fern - (Devil's-club) - (Hw) & Ba - C
Deer Fern - Twistedstalk - Hw - C & Ba
ecosystems on shallow soils on excessively steep slopes*
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw
Ovel-leaved & Alaskan Blueberry - Ba - Hw*
Ovel-leaved & Alaskan Blueberry - Cy - Hm & Hw*
ecosystems on shallow soils on rock outcrops & adjacent slopes*
Salal - Alaskan Blueberry & Red Huckleberry - C - Hw
Submontane Wetter Maritime Northern CWH Variant
Sitka spruce & related ecosystems along the sea coast littoral belt*
non-forested ecosystems on rocks* or in aquatic environments*
Goldthread - Skunk Cabbage - (Hw) - C & Ss
Leucolepis - Sword Fern - (Hw) & Ba - Ss
Sword Fern - (Devil's-club) - (Hw) & Ba - C
Foamflower - Deer & Sword Fern - Ba & Hw
Sword & Deer Fern - Ba - Hw
Foamflower - Sword Fern - (Hw) - C
Sword & Deer Fern - Ba - Hw
ecosystems on shallow soils on excessively steep slopes*
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw
ecosystems on shallow soils on rock outcrops along coastline*
Pacific Ocean
Pacific Ocean
marine or fluvial* (deltaic) materials
compacted till
alluvial materials
compacted till (fluvial materials)
moisture (and nutrient) gradient
*tentative - not sampled and studied
organic materials
mineral materials
conglomerate bedrock
Amabilis fir
Douglas-fir
Mountain hemlock
Sitka spruce
Western hemlock
Western redcedar
Yellow-cedar

Figure 3. Representative sequence and topographic relationship of biogeocoenotic associations in the Submontane and Montane variants of the Wetter Maritime Northern CWH Subzone.

Fig. 3. Schematic diagram showing topographic relationships of biogeocoenotic associations (Klinka et al. 1980b:17)

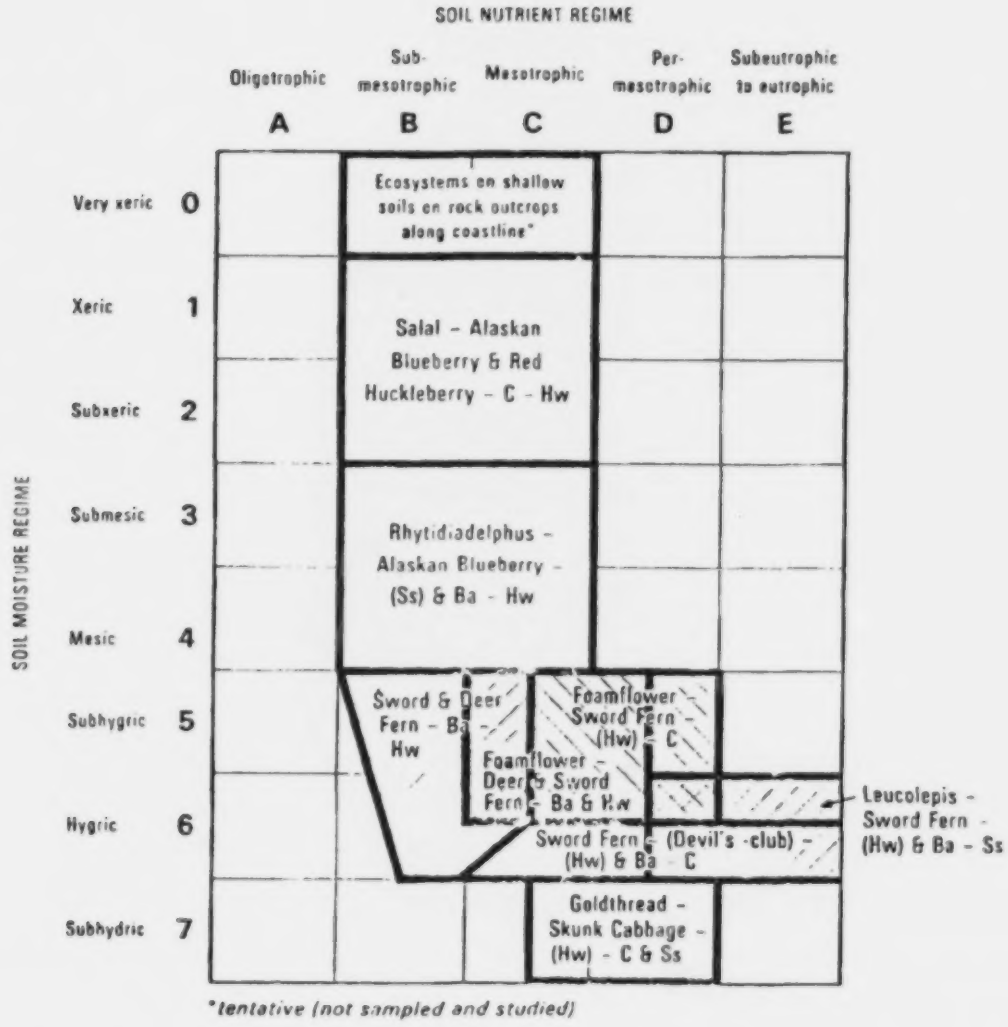
SOIL NUTRIENT REGIME
Oligotrophic
Sub-mesotrophic
Mesotrophic
Per-mesotrophic
Subeutrophic to eutrophic
A
B
C
D
E
SOIL MOISTURE REGIME
Very xeric 0
Xeric 1
Subxeric 2
Submesic 3
Mesic 4
Subhygric 5
Hygric 6
Subhydric 7
Ecosystems on shallow soils on rock outcrops along coastline*
Salal - Alaskan Blueberry & Red Huckleberry - C - Hw
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw
Sword & Deer Fern - Ba - Hw
Foamflower - Sword Fern - (Hw) - C
Foamflower - Deer & Sword Fern - Ba & Hw
Leucolepis - Sword Fern - (Hw) & Ba - Ss
Sword Fern - (Devil's -club) - (Hw) & Ba - C
Goldthread - Skunk Cabbage - (Hw) - C & Ss
*tentative (not sampled and studied)

Figure 4. Relationship of biogeocoenotic associations to soil moisture and nutrient regime in the Submontane Wetter Maritime Northern CWH Variant.

Fig. 4. Edaphic grid showing relationship of biogeocoenotic associations to soil moisture and nutrient regimes (Klinka et al. 1980b:18)

were used as tools for the identification of treatment units. In the case of one of the biogeoclimatic variants in the Koprino, the edaphic grid does not fully distinguish among biogeocoenotic associations -- there is considerable overlap in the 5-6/C-D area. Another device, having biogeoclimatic variants on the vertical axis and edaphic factors (primarily moisture regime, soil depth, and slope gradient) on the horizontal axis, was also used to relate biogeocoenotic associations to environmental conditions (Fig. 5). This device was proposed for use as an identification tool for use on disturbed or seral sites. It may be used for mapping by photo-interpretaiton, which relies heavily on edaphic features. It also shows affinities among biogeocoenotic associations, and was used as a basis for grouping associations into treatment units.

Interpretation

Biogeoclimatic and biogeocoenotic units are part of the natural taxonomic classification of the MOF. These units are not modified to accommodate the user, though interpretive information may be presented. The MOF also uses technical classifications, in which taxonomic units are grouped into fewer interpretive classes referred to as treatment units.

At the biogeoclimatic level, all interpretive information developed so far has been presented for taxonomic units. But Klinka et al. (1979) presented a proposed grouping of 18 biogeoclimatic units into nine treatment units. Use of these treatment units was suggested as fire protection zones, forest inventory zones, productivity zones, and for the intensive forestry program. The treatment units will be used in the next edition of the guide for tree species selection and site preparation in the Vancouver Forest Region.

In the Koprino study, biogeocoenotic units were grouped into treatment units for resource planning at the subunit (or watershed) level. Criteria for

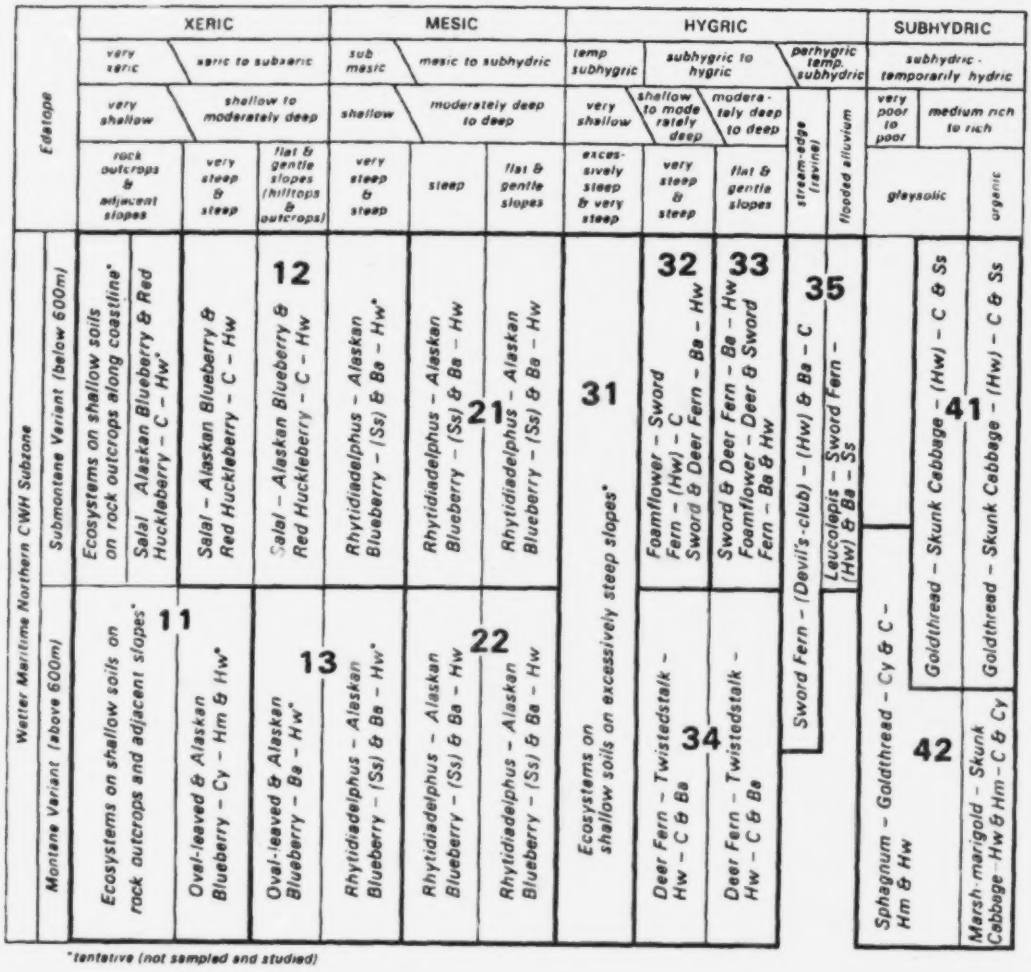
Edatope
XERIC
MESIC
HYGRIC
SUBHYDRIC
very xeric
xeric to subxeric
sub mesic
mesic to subhydric
temp subhygric
subhygric to hygric
perhygric temp. subhydric
subhydric - temporarily hydric
very shallow
shallow to moderately deep
shallow
moderately deep to deep
very shallow
shallow to moderately deep
moderately deep to deep
very poor to poor
medium rich to rich
rock outcrops & adjacent slopes
very steep & steep
flat & gentle slopes (hilltops & outcrops)
very steep & steep
steep
flat & gentle slopes
excessively steep & very steep
very steep & steep
flat & gentle slopes
stream-edge (ravine)
flooded alluvium
glaysolic
organic
Wetter Maritime Northern CWH Subzone
Submontane Variant (below 600m)
Montane Variant (above 600m)
Ecosystems on shallow soils on rock outcrops along coastline*
Salal - Alaskan Blueberry & Red Huckleberry - C - Hw*
Salal - Alaskan Blueberry & Red Huckleberry - C - Hw
Salal - Alaskan Blueberry & Red Huckleberry - C - Hw
12
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw*
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw
21
Ecosystems on shallow soils on rock outcrops and adjacent slopes*
11
Oval-leaved & Alaskan Blueberry - Cy - Hm & Hw*
Oval-leaved & Alaskan Blueberry - Ba - Hw*
13
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw*
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw
Rhytidiadelphus - Alaskan Blueberry - (Ss) & Ba - Hw
22
Ecosystems on shallow soils on excessively steep slopes*
31
Foamflower - Sword Fern - (Hw) - C
Sword & Deer Fern - Ba - Hw
32
Deer Fern - Twistedstalk - Hw - C & Ba
34
Sword & Deer Fern - Ba - Hw
Foamflower - Deer & Sword Fern - Ba & Hw
33
Deer Fern - Twistedstalk - Hw - C & Ba
Sword Fern - (Devil's-club) - (Hw) & Ba - C
Leucolepis - Sword Fern - (Hw) & Ba - Ss
35
Sphagnum - Goldthread - Cy & C - Hm & Hw
Goldthread - Skunk Cabbage - (Hw) - C & Ss
41
Goldthread - Skunk Cabbage - (Hw) - C & Ss
Marsh marigold - Skunk Cabbage - Hw & Hm - C & Cy
42
*tentative (not sampled and studied)

Figure 6. Relationships between biogeocoenotic and treatment units (to be discussed in the next section) in the Koprino River watershed. Depth classes are very shallow (25 cm or less), shallow (26-50 cm), moderately deep (51-100 cm), and deep (101 cm and over). Slope gradient classes are flat (0-5%), gentle (6-34%), steep (35-49%), very steep (50-79%), and excessively steep (>80%). Some special edaphic classes, (*e.g.* stream-edge or flooded-alluvium) were used when these were thought to be more explicit in depicting the controlling environmental factors for the respective biogeocoenotic units. Following a similar approach a subhydric class was subdivided by nutrient regime and the nature of soil materials.

Fig. 5. Presentations device showing relationship between biogeocoenotic associations and environmental factors (Klinka et al. 1980b:21).

grouping were: a) similar vegetation-environment relationships, proposed silvicultural regime, and forest productivity; and b) similar sensitivity to disturbance affecting regeneration and productivity. Biogeocoenotic units could be grouped at the association or the type level; thus, a treatment unit might include one or more associations and a type from another association.

In the descriptions of treatment units, component biogeocoenotic types and associations were identified. Salient features of the vegetation and environment were summarized. Comments on browsing and presence of rock outcrops were sometimes included. The value of the unit for forestry, wildlife, fisheries, and recreation was noted, and recommendations for use were made. Sensitivity and constraints were discussed. Recommendations were made for harvesting methods, silvicultural regime, and road construction. Evaluation and interpretive information about treatment units was also presented in tabular form on the Resource Management map sheet included with the report.

Mapping

Biogeoclimatic units of central and southern Vancouver Island have been mapped at a scale of 1:500,000; this map is included with the report by Klinka et al. (1979). A similar mapping program for the rest of Vancouver Island is in progress. Biogeocoenotic units of the Koprino were mapped at a scale of 1:15,840, but this map is a working copy only. It was transformed to a 1:20,000 map of treatment units for resource planning at the subunit level, published with the Koprino report (Klinka et al. 1980b).

Biogeoclimatic mapping begins with a review of ecosystem studies conducted in or near the mapping area. Biogeoclimatic units are characterized, on the basis of environmental and floristic differentiating features. A draft map,

based on physiography and the extrapolation of elevational limits, may be prepared. Mapping is carried out along selected transects by ground and air survey. The ground survey includes brief descriptions of vegetation and soils of zonal ecosystems, which are used to verify and document the classification. Boundaries drawn in the field are based on the occurrence of zonal ecosystems, presence of characteristic combinations of species, and the distribution of edaphic ecosystems. They are finalized after all fieldwork is completed and climate data are analyzed. Boundaries outside transects are extrapolated on the basis of elevation and physiography.

On central Vancouver Island, the map units were biogeoclimatic variants. In two cases, variants which were too finely distributed to be mapped separately were grouped into composite units. The authors estimated that up to 15% of a map unit may belong to an adjacent map unit.

Biogeocoenotic mapping in the Koprino study followed sampling and classification. A key to biogeocoenotic units was prepared, using readily identifiable features of the vegetation and environment as characters. Mapping was based on a combination of ground surveys and interpretation of black and white 1:15,840 air photographs. Initially, some mapping was done on the ground in the vicinity of sample plots. Air photo mapping was followed by ground checks. Once the correlation of units with air photo characters was established, use of air photos for mapping increased. Characteristics of the tree layer and environmental features, such as elevation, topographic position, and slope gradient, were used in photo-interpretation.

The map units used in biogeocoenotic mapping varied in taxonomic level; some map units were biogeocoenotic types, others were associations, and others were complexes of associations.

The biogeocoenotic map was then transformed to a 1:20,000 treatment unit map, using a set of integrative rules. The map units were individual treatment units or comlexes of two treatment units. Map units may include up to 15% ecosystems that belong in other treatment units. For each map unit, color coding indicates the forest productivity on a four-point scale, and the management sensitivity on a three-point scale.

THE BIOPHYSICAL CLASSIFICATION PROGRAM OF THE MINISTRY OF ENVIRONMENT

The Terrestrial Studies Branch (TSB) of the Ministry of Environment is a multi-disciplinary group responsible for inventory and analysis of natural resources. The biophysical approach of the TSB originated with the Canada Land Inventory and the British Columbia Land Inventory (van Barneveld 1976). Personnel and methodology of this program became part of the Resource Analysis Unit of the Environment and Land Use Secretariat, which evolved into the Resource Analysis Branch (Walmsley and van Barneveld 1977), and finally the Terrestrial Studies Branch of the Ministry of Environment.

This group has produced a variety of reports and maps for project areas throughout the province, and others are in progress. Three types of projects have been selected for discussion here, because of their relevance to the objectives of the IWIFR program:

Biophysical vegetation classification and mapping. Preliminary maps of biophysical forest regions, zones and subzones of Vancouver Island have been completed by A. Harcombe, TSB, Kelowna. The associated report, which will include descriptions of vegetation types, is in preparation. As an example of a completed report treating a comparable project, the vegetation classification of the northeast coal area (Harcombe 1978) is discussed.

Biophysical capability mapping for ungulates. The TSB has an ongoing program of biophysical capability mapping for ungulates, but no such mapping has been carried out by the TSB on Vancouver Island. The program has been described recently by Demarchi and Fuhr (1979) and Demarchi et al. (1981).

Special projects. Several special projects of the TSB have included among their objectives the development of classification units that could be readily interpreted for wildlife. Included are studies of the Lardeau Flats (Rafiq 1980), the Pend-d'Oreille Valley (Vold et al. 1980), and the Pine/Moberly area (Harcombe et al. 1980, Fuhr 1980).

Objectives

The objectives of the biophysical classification program of the TSB are:

1. To differentiate and classify ecologically significant segments of the land surface.
2. To identify opportunities and limitations for particular types or combinations of land use, and hence provide a management tool for resource planners.
3. To relate management practice to land productivity in a quantitative and qualitative manner so that management alternatives can be identified (Walmsley and van Barneveld 1977).

Classification projects are undertaken in response to requests from managers, who may have more specific objectives in mind. These requests are usually approached from a comprehensive perspective by the TSB, so that the basic objective of ensuring the consideration of all resource values in management is always retained (J. van Barneveld, pers. comm.)

Philosophy

The biophysical land classification system of the TSB is designed to differentiate the landscape into ecologically significant segments, and to classify these segments. Ecological significance, in this context, refers to "the energy flow, the physical and biological complexes which facilitate this energy flow, and the mechanisms and sequences by which the energy flow may take place" (Walmsley and van Barneveld 1977:45). Thus, a biophysical system is understood to be a system of processes, rather than a system of attributes (J. van Barneveld, pers. comm.).

Ideally, a classification system to be applied to land management should reflect ecological processes. In practice, processes are difficult to measure in the field; morphological characteristics are relatively easy to measure. Thus, the classification system is based on morphological attributes, which are used as indicators of function. The relationship between attributes and processes must be determined through research (Walmsley and van Barneveld 1977).

The biophysical classification system is hierarchical. At each level of the hierarchy, appropriate classification parameters from various disciplines are taken into consideration. At given levels, different parameters contribute best to the differentiation of ecologically significant units. For example, macroclimatic parameters, reflecting the influence of major air masses, are highly significant in determining broad vegetation patterns in British Columbia. Local vegetation patterns are controlled by meso- and micro- climatic parameters as well as terrain and soil parameters (van Barneveld 1978, pers. comm.).

The interaction that occurs among disciplines is one of the central features of the biophysical system as applied by the TSB. In the planning

stage and at intervals during the fieldwork, personnel from the various disciplines communicate their perceptions of the biological, physical, and bio-physical processes that are important in their fields. The object of this interaction is the perception of the same ecologically significant units by personnel from the various disciplines (J. van Barneveld, pers. comm.).

The TSB does not emphasize the "natural taxonomic" qualities of the biophysical classification system, but presents it as a pragmatic mechanism which brings together ecological information in a form which facilitates understanding and communication (Walmsley and van Barneveld 1977).

Biophysical vegetation classification and mapping

As part of an overall biophysical classification, vegetation analysis typically includes the classification and mapping of forest regions, sections, zones, and subzones, and the classification of vegetation types. Vegetation landscape units (formerly present ecological condition units) may also be mapped. The following description is based on Harcombe (1978), Harcombe (1981), and on interviews with J. van Barneveld and A. Harcombe.

Stratification and sampling The overall biophysical methodology uses a stepwise-stratified selective sampling procedure (Walmsley and van Barneveld 1977). At each step, the stratification is based on a specific discipline. The first set of stratification parameters are biophysical forest regions, sections, zones and subzones. Data from existing sources, such as ecological studies and maps, forest cover maps, and sometimes a few representative transects of the landscape, serve to tentatively define the major zones and subzones. Often the major regions and sections can also be defined. The amount of differentiation possible at this stage depends on available information. Additional regions, sections, zones and subzones may be defined after the fieldwork is completed.

At the next stage, stratification is based on the Terrain Classification System (Resource Analysis Unit 1976). This system provides for the mapping of landforms and geomorphic processes which have modified and are now modifying the landforms (Walmsley and van Barneveld 1977). Further differentiation of the landscape is based on soil development at the soil subgroup level of the Canadian System of Soil Classification (Canada Soil Survey Committee 1978). Landform - soil subgroup units are then stratified into units of vegetation that are homogeneous with respect to species composition and species abundance in each of the vegetation strata (Walmsley and van Barneveld 1977).

Within each biophysical forest zone, variations in local climate, soil, landscape position, and history result in a variety of sites, or areas of homogeneous soil and vegetation. As many as possible of this variety of sites are sampled, including climatic climax, edaphic climax, and successional stands. Commonly, climax and maturing seral stands have been sampled more heavily than early seral stages, because they provided more information about successional patterns of trees.

Plot location in the field is selective. Criteria for selection include representativeness, replication, areal extent, and homogeneity. Plots are selected to represent a particular prestratified set of environmental parameters. This is intended to allow testing of hypotheses regarding similarity and distribution limits of vegetation. If the hypotheses are confirmed, a minimum number of replicates is needed; if they are rejected, then more replicates will be needed to define the vegetation types. The plot area must be large enough to adequately represent the environmental conditions in question, and it must be homogeneous . Plots normally include a single soil polypedon and are homogeneous with respect to vegetation composition, vegetation structure, and environmental factors such as slope position and slope drainage (Walmsley et al. 1980).

Plot size is variable; about 1/5 acre (800 m^2) is typical for forested sites. Plot boundaries are not laid out. Standard site and vegetation data sheets (Appendix 1) are filled out according to procedures described by Walmsley et al. (1980). Percent cover and distribution class (Walmsley et al. 1980:137) are used to quantify abundance and record spatial patterns of plant species. Other vegetation characteristics, such as phenology, vigor, and epiphyte cover may or may not be recorded, depending on the objectives of the the project and the abilities of the field crew. The mensuration data sheet and the wildlife data sheet may be completed wholly or in part, depending on project objectives. Soil data sheets are normally completed by other TSB personnel as part of a separate soil survey, but enough soil data are collected by the vegetation team to identify the soil unit.

Sample size is variable, depending on the study area and objectives. The classification and mapping of vegetation of the northeast coal study area (covered by 30 1:50,000 map sheets) was based on 1,069 plots (Harcombe 1978), or 1 per 25 km^2. The classification and mapping of Vancouver Island was based on 885 plots (Harcombe 1981), or 1 per 36 km^2.

Analysis Vegetation data are analyzed independently of other environmental data. The vegetation classification program presently used by the TSB is COENOS II, based on COENOS I of Ceska (1975) and modified by the TSB. This program first uses dissimilarity analysis (Arlidge and Kovats 1969) to define groups of plots. Presence/absence data for a selected floristic list are used to create a hierarchical, dichotomous classification of plots. At each step, the total set of vegetation plots is divided into two subsets such that the measure of dissimilarity between the two subsets is maximized. The second subprogram, cluster analysis, employs quantitative data on species abundance. Cluster analysis (Hagmeier 1975) is used to order the plots within plotgroups, to order the plotgroups, and to order the species. Homogeneity

within groups is expressed in terms of a similarity coefficient. The program produces a dendrogram, which shows relationships among plotgroups. It also produces tables showing cover values of each species in each plot, and constancy (frequency of occurrence) values for each species in each plotgroup (Ceska 1975).

The final groups produced by COENOS are assessed subjectively. Uniform application by the computer of the stopping rule required for dissimilarity analysis may result in some groups which are too narrowly defined to be useful. The classifier may choose to combine, or occasionally to split, the groups produced by COENOS. The final result is the definition of vegetation types. Vegetation types are defined as units of vegetation, the members of which have a variable number of floristic characteristics in common with at least some of the other members of the same type (Harcombe 1978). The term does not imply any particular level in a classification hierarchy. Some vegetation types and groups of vegetation types have a high degree of internal floristic similarity. Heterogeneous groups may also be produced by COENOS, usually where sampling frequency was low. Such groups are not necessarily designated vegetation types by the classifier.

Classification units Classification procedures of the TSB result in disciplinary units, such as vegetation types, and biophysical units -- units that are defined on the basis of specified biological and physical parameters, and are considered ecologically significant. Biophysical units based in part on vegetation are summarized in Table 4.

Two biophysical forest regions have been described for Vancouver Island: The Inner and the Outer Coastal Regions. Environmental descriptions of these regions provided by Harcombe (1981) are general and emphasize contrasting features. General descriptions of overall climate, soils, humus characteristics, and successional patterns are included. The characteristic zone is given.

TABLE 4. Biophysical Units of the TSB

Forest region -- an area in which the broad regional climate and physiography determine a definitive vegetation pattern (Harcombe 1981). Typically, the region is characterized by a "key zone", which may occur with various combinations of zones and subzones. In flat terrain, the key zone may be the only one present; in mountainous terrain, the key zone is usually the lower one (Thompson et al. 1980).

Forest section -- A subdivision of a forest region distinguished on the basis of variations in the vertical sequence of zones or subzones, or variations in the edaphic inclusions of zones, where such variations are a reflection of climate (Walmsley and van Barneveld 1977).

Forest zone -- An area within a forest region in which the dominant vegetation (usually species composition of the tree canopy) of climax stands on similar soils and terrain is identical (Harcombe 1981). Differences in climax vegetation within a zone are due to variations in soil or topography (Thompson et al. 1980).

Forest subzone -- An area within a forest zone defined on the basis of climate-related successional trends or growth form of the dominant vegetation (usually the tree canopy) (Harcombe 1981).

Biophysical type -- A biophysical unit consisting of a soil unit (at the soil series or other appropriate level) with its climax vegetation type(s) and all potentially associated seral vegetation types (Harcombe 1978, J. van Barneveld, pers. comm.).

Vegetation landscape -- A biophysical mapping unit representing areas of closely related soils, over which similar trends in successional and climax vegetation occur (Thompson et al. 1980). Vegetation landscapes may be mapped at a variety of levels of generalization (J. van Barneveld, pers. comm.).

Stage -- A successional stage of a vegetation landscape unit (Thompson et al. 1980).

Descriptions of biophysical forest sections for Vancouver Island are in preparation.

Five biophysical forest zones have been described for Vancouver Island, two of which occur in both regions (Harcombe 1981). A separate description is provided for each zone in each region, as corresponding zones in different regions are generally considered distinct ecological units (Harcombe 1978). Descriptions of forest zones in the legend (Harcombe 1981)(Table 5) typically include: geographic location, major climatic climax tree species, extent and effects of disturbance, climate, and limitations to vegetative productivity. A list of common tree species, the elevational range, and some climatic parameters (May to September precipitation, climatic moisture deficit or surplus, freeze-free period, effective growing degree days) are also given.

One or two subzones have been described for each forest zone on Vancouver Island. Descriptions of subzones are similar to those of zones, but are limited to those characteristics which distinguish the subzone from the rest of the zone. Common tree species, elevational range, and climate characteristics are given for subzones.

Regions, zones, subzones, and vegetation types of Vancouver Island will be described in a report which is in preparation. This report will be similar in scope to the vegetation report for the northeast coal area (Harcombe 1978). Because the Vancouver Island report is not yet available, the northeast coal report is discussed here as an example of a similar document.

In the northeast coal report, forest regions, zones and subzones were described. Descriptions include approximately the same type of information as the Vancouver Island legend, except that successional trends and vegetation structure are described more fully. Climatic parameters are not given.

5. Biophysical Forest Zones and Subzones

Map Symbol [1]	Name		Environmental Description	Common Tree Species[4] (see box 6)	Elevational Ranges	Selected Climatic Parameters[5]	
	Zone[2]	Subzone[3]					
IC CgF-wC	Coastal grand fir - western red cedar		zone restricted to south-eastern coastal strip; forests dominated by coast Douglas-fir, seral tree to grand fir and/or western red cedar climax on deep soil materials; coast Douglas-fir may form edaphic climax on shallow to bedrock and south-facing sites; land area intensively disturbed by logging and settlement; driest zone on Vancouver Island; major limiting factor to vegetative productivity is extended summer moisture deficit and extensive shallow soils	gF,wC,D, Ar,gO,bM, wOo,(bCo)	0-300 m	M-S ppt CMD/CMS EGDD FFP	125 to 200 mm -200 to -150 mm 750 to 1000+ °C days 160 to 200 days
IC CgF-wC a		Pacific madrone	seral forests dominated by Coast Douglas-fir; drier sites often with Pacific madrone as a seral or edaphic climax tree species	gF,wC,D, Ar,gO,bM, wOo,(bCo)	0-300 m	M-S ppt CMD/CMS EGDD	125 to 200 mm -200 to -150 mm 750 to 1000+ °C days

Table 5. Excerpt from vegetation legend for Vancouver Island (Harcombe 1981). Preliminary; used with permission.

One hundred ten vegetation types in fifteen groups were delineated for the northeast coal area. Relationships among types and groups of types are shown in a dendrogram (Fig. 6). Descriptions of these types and groups of types (Fig. 7) are provided in an appendix to the report. For each group of vegetation types, the floristic similarities and internal variations are described briefly. Descriptions of vegetation types include the constant species and often some dominant and common species for each vegetation layer. An indication of the cover of vegetation layers is sometimes given (e.g. dense, sparse, scattered). The zone, the subzone, and the successional stage(s) represented by the vegetation type are given. Descriptions of the physical habitat typically include surficial material, relief, and moisture regime. A list of soil association components on which the vegetation type has been found is provided.

A key to vegetation types of the northeast coal area (Harcombe n.d.) (Fig. 8) is available from the TSB. The key, which is based strictly on floristic characters, follows the dichotomous divisions shown in the dendrogram (Fig. 6). According to Harcombe (1978), the 46-page key is quite specialized and requires a good understanding of plant taxonomy and ecology to be used correctly in the field.

Floristic and physical data from the northeast coal study may be obtained from the TSB. In addition to the raw vegetation data, coded by plot, synthesis tables and constancy tables are available. Synthesis tables give cover values for each species in each plot, classified by vegetation type. Constancy tables summarize the frequency of occurrence of each species in each vegetation type. Physical data are available for each plot, grouped by vegetation type.

Vegetation types may be used along with soil units to define biophysical types. A biophysical type is a biophysical unit characterized by a soil unit (in this case a soil association component), its climax vegetation type(s),

FIGURE E.1

DENDROGRAM OF VEGETATION TYPES AND SINGLE RELEVES

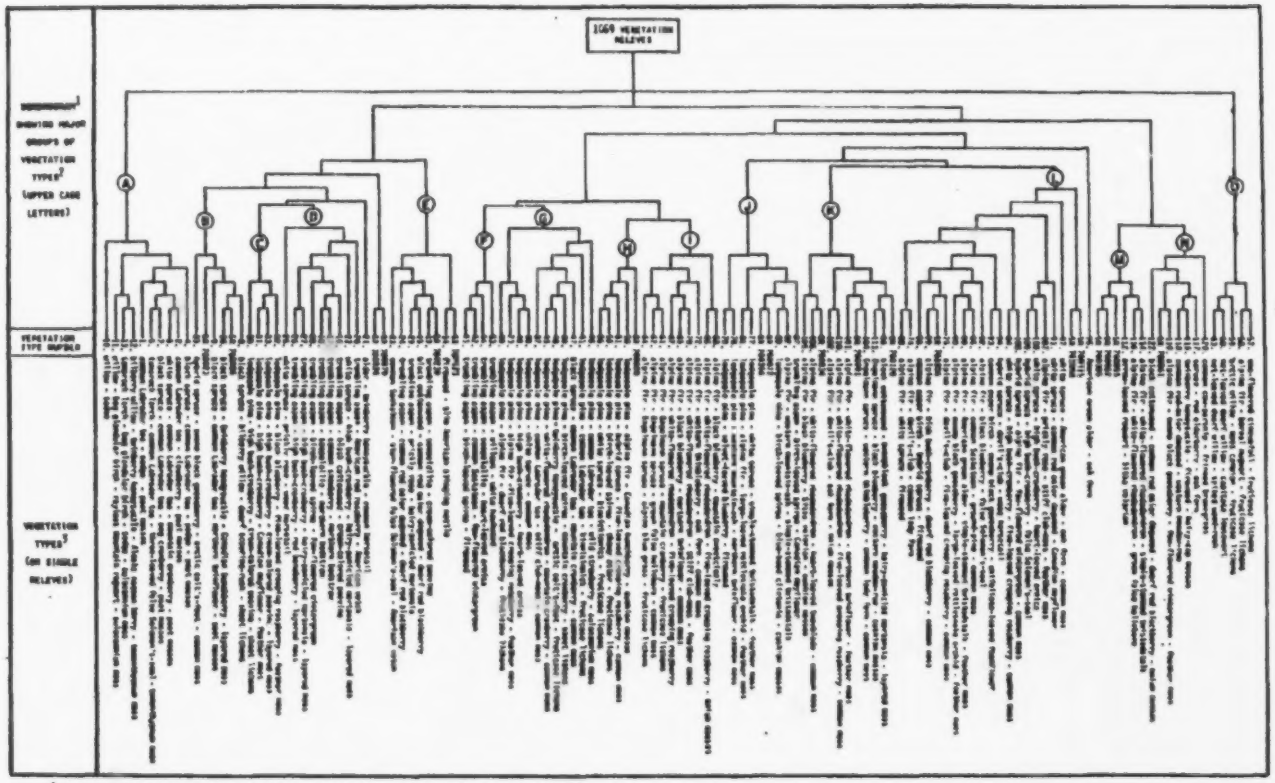

Fig. 6. Dendrogram showing relationships among vegetation types (Harcombe 1978:E4).

Group C

Group C contains eighteen plots in four vegetation types. These types are seral forests with a mixed trembling aspen - lodgepole pine tree canopy. Differences are primarily attributed to zonal variation. Constantly occurring species include birch-leaved spirea, high bush-cranberry, fireweed, northern twinflower, Canadian bunchberry, Canadian mayflower, dwarf red blackberry, and common moss.

(30) Lodgepole pine - high bush-cranberry - cream-colored peavine - sheet lichens

This vegetation type usually has a mixed lodgepole pine - trembling aspen forest cover; one sample, however, has no tree canopy and another only has lodgepole pine in the tall shrub layer. Bebb's willow is constantly occurring in both shrub layers. Other constant shrubs include soopolallie, high bush-cranberry, birch-leaved spirea, twinberry honeysuckle, and Nootka rose. The open herb layer is well represented; constantly present herbs are few-flowered wintergreen, northern bedstraw, fireweed, northern twinflower, dwarf red blackberry, Canadian bunchberry, and American vetch. Several others are common. The moss layer is not well developed; sheet lichens and cushion mosses are usually present but have only a sparse cover.

This vegetation type represents a young seral stage on shedding sites within the Subalpine Engelmann spruce-alpine fir zone, on drier aspects. It occurs on well drained morainal or colluvial material on strongly to extremely sloping sites. This type results after severe burning that allows some trembling aspen invasion and dominance of Bebb's willow. Regeneration of the climax trees is very slow, partially due to removal of seed source and partially due to site dryness.

This vegetation type has been found on the following soil association components: DZ1, HS2, HS6, TD2.

Fig. 7. Sample description of a vegetation type (Harcombe 1978:E13).

-13-

LAYER	COMMON NAME
35a	Final Group 23 - 2 plots
	Constant Species
B2	common Saskatoon
B2	Nootka rose
C	false Solomon's-seal
C	broad-leaved arnica
C	northern bedstraw
C	cream-colored peavine
C	American vetch
D	brachythecium moss
36a	Final Group 24 - 12 plots
	Diagnostic Frequent Associates
A1	common paper birch
A2	common paper birch
B1	common paper birch
B2	Nootka rose
B2	common paper birch
C	broad-leaved arnica
C	Hooker's fairybells
D	brachythecium moss
	Preferential Constants
B2	high bush-cranberry
37a	13 plots
	Diagnostic Frequent Associates
A1	black cottonwood
A2	black cottonwood
B1	black cottonwood
B2	American red raspberry
B2	common red osier dogwood
B2	black cottonwood
C	star-flowered false Solomon's-seal
C	false Solomon's-seal
C	common horsetail
	Preferential Frequent Associates
C	common cow parsnip
C	arctic colt's-foot
	Go to Step 38, page 14

LAYER	COMMON NAME
35b	36 plots
	Diagnostic Frequent Associates
A1	black cottonwood
A2	trembling aspen
A2	black cottonwood
B1	black cottonwood
B1	Bebb's willow
B2	prickly rose
B2	high bush-cranberry
B2	soopolallie
B2	common red osier dogwood
B2	black cottonwood
B2	Bebb's willow
B2	white spruce
C	dwarf red blackberry
C	fireweed
C	hairy-panicled mertensia
C	Canada violet
C	ground-cedar
C	common pink pyrola
C	Canadian bunchberry
C	Douglas' aster
C	one-sided wintergreen
C	northern twinflower
	Go to Step 36
36b	24 plots
	Diagnostic Frequent Associates
C	common cow parsnip
C	fringed brome grass
C	fuzzy-spiked wild rye grass
C	rough-fruited fairybells
	Preferential Constants
B2	prickly rose
	Go to Step 37
37b	11 plots
	Diagnostic Frequent Associates
B1	white spruce
B2	Pacific willow
C	dwarf blueberry
C	common red Indian paintbrush
	Preferential Constants
B1	trembling aspen
C	Douglas' aster
	Preferential Frequent Associates
B1	Bebb's willow
B2	soopolallie
B2	trembling aspen
B2	birch-leaved spirea
B2	Bebb's willow
B2	white spruce
C	fuzzy-spiked wild rye grass
C	mountain sweetcicely
	Go to Step 39, page 14

Fig. 8. Sample page of key to vegetation types of the northeast coal area (Harcombe n.d.:13). Preliminary; used with permission.

and all potentially associated seral vegetation types. Soil association components for the northeast coal study area have been identified by Vold et al. (1977). Harcombe (1978) provided a soils-vegetation (biophysical) legend which shows the occurrence of vegetation types on soil association components (Table 6). Each row represents a biophysical type. A vegetation type may be associated with a number of soil association components. A soil association component typically supports several climax and several seral vegetation types.

Mapping Biophysical vegetation studies typically result in mapping of vegetation regions, zones and subzones. Zonation of Vancouver Island has been mapped at a working scale of 1:50,000; the maps are published at 1:100,000.

Biophysical regions, zones and subzones are tentatively mapped prior to fieldwork, on the basis of existing ecological studies and maps, forest cover maps and air photographs. Maps are refined during the course of fieldwork. In addition to the formal plots used for classification, mapping is based on a number of elevational transects. The transects are chosen to cover a variety of landforms, bedrock types, and aspects, distributed throughout the study area. Final map unit boundaries commonly follow boundaries of soil associations, which are mapped by TSB pedologists, but may follow observed breaks in the vegetation.

The forest zonation maps of the northeast coal area, which were published at 1:50,000, show present ecological condition units as well as forest regions, zones and subzones. Present ecological condition units, which were forerunners of vegetation landscape units, illustrate major climax and successional communities, as related to time, soil and terrain, and/or topography. For each map unit, the following information is provided for the expected climax and for the present condition: ecological state (e.g. young seral, young edaphic climax, maturing climatic climax), characteristic

SOILS-VEGETATION (BIOPHYSICAL) LEGEND OF THE BOREAL WHITE SPRUCE ZONE

SURFICIAL MATERIAL	SOIL[1] ASSOCIATION	SOIL[2] ASSO. COMP. SYMBOL	MODAL[3] SOIL DEV'L	ASSO.[3] SOIL DEV'L	TERRAIN[4] SYMBOL	VEGETATION TYPES[5] CLIMAX	VEGETATION TYPES[5] SERAL	REMARKS
Morainal	Edson	ED1	O.GL		Mbm	25.	38,9,20,17,28,18,39,73	dominantly seral trembling aspen stands, with wetland communities developed on EDB.
		ED3	O.GL	BR.GL	Mbm	25*	17*,18*,28*	
		ED5	O.GL	L.O.GL	Mbv			
		ED7	O.GL	GL.O.GL	Mbm	25*	20,27	
		EDB	O.GL	.G	Mbm	13*,12*,7*		
	Fellers	FE1	BR.GL		Mb	15,46,25*	28,18,26,17,22,39,47,46	seral trembling aspen stands common; pioneer seral willow thickets on gleyed components; wetlands on gleysols.
		FE4	BR.GL	GL.O.G O.GL	Mbv	36,25	36,27,48	
		FE7	BR.GL	GL.BR.GL	Mb	36*,25*	36*,27*,48*	
	Lodge	LG1	BR.GL		Fv/Mbm	25,33,47*,108*	16,46,33,39,38,37,45	dominantly lodgepole pine stands, usually with regenerating black spruce or occasionally, white spruce (aspen commonly intermixed); pioneer willow thickets on gleyed component; wetland communities on LGB.
		LG2	BR.GL	O.GL	Fv/Mbm	47,36	47,37,46,40,36	
		LG3	BR.GL	P.GL	Fv/Mbm	25*	45,48*	
		LG4	BR.GL		Fv/Mbm	25*,33*,47*	37*,46*,40*,36*	
		LG7	BR.GL	GL.BR.GL	Fv/Mbm	36,119	36,43*	
		LGB	BR.GL	.G	Fv/Mbm	13,12*,7*		
	Moberly[6]	MO1	BR.GL		Mb	33,108,47,25*	33,40,39,41,31,44,37,108, 19,38,27,48,45,43,47,46, 18,28,73,26	dominantly lodgepole pine seral stands, usually with white spruce regeneration (occasionally black spruce) trembling aspen stands on finer textured units or after severe burning; climax white spruce stands rare.
		MO2	BR.GL	DG.EB	Mb	107,	24,43,45,107,19,44,73	
		MO3	BR.GL	P.GL	Mb	33*,108*,25*	33*,108*,17*,40*,38*	
		MO4	BR.GL	DG.EB O.EB	Mb		43,46	
		MO6	L.BR.GL	BR.GL	Mv	108,33,35,15	43,108,101,27,33,18,28, 35,37,41,19,45,39,79,78	
		MO7	BR.GL	GL.BR.GL	Mb	33,65,67,	56,51,48,50,31,33,45,65, 67,41,	
		MOB	BR.GL	.G	Mb	36,13,12,	36,39,45,	
	Smoky	SY3	O.G	O.MG	Mb	9,15,	19,	wetland environment, with pioneer seral willows or black spruce and tamarack
Organic	Eaglesham	EG1	.M		O^B1			wetlands, often with lodgepole pine and black spruce cover; tree cover may be absent
	Kenzie	KZ1	.M		O^B1	9,106,104,10,12,1.5, 7.6,		organic wetlands dominant; may be treed with black spruce and tamarack; ranges from sedge fens to peat bogs
		KZ3	.M	.F	O^B1	10,1,7,11,5.4,		
		KZ4	.M	T.M	O^B1	36,9,13,5.4,	36,	
Lacustrine	Devereau	DU1	O.GL		Ln		17,18,	usually cultivated, with trembling aspen seral stands scattered
		DU3	O.GL	O.GL BR.GL	Ln		17,	
	Dickebusch	DB1	BR.GL		Lmtb	15,	28,24,22,18,45,46,19	seral trembling aspen stands common
		DB2	BR.GL	O.EB DG.EB	Lmtb	23,	18,24,41,44,37,92	
		DB4	BR.GL		Lmtb	108,	44,20,108,	
		DA7	BR.GL	GL.BR.GL	Lmtb			
		DB3	BR.GL	.G	Lmtb	9,	18,	
	Pat Creek	PC1	O.GL		Lmtb	15,	38,17,18,16,19,28,43,	black cottonwood or white spruce climax stands; trembling aspen seral stands dominant
		PC7	O.GL	GL.O.GL	Lmtb	15,25,4,	16,17,38,18,	

Table 6. Excerpt from biophysical legend for the northeast coal area (Harcombe 1978:F2).

dominant tree species, and macrophysiognomy (e.g. coniferous forested dense, broad-leaved forested open, recently logged, wetland:bog). In an expanded legend, brief habitat descriptions are provided for each type of mapping unit. Descriptions include important environmental characteristics, such as soil texture, surficial material, and slope position.

Present ecological condition units represent an attempt to generalize the existing vegetation and landscape into categories reflecting significant ecological entities. Therefore, the tree species appearing in the present condition label are not necessarily frequent within the stands in that category (Walmsley and van Barneveld 1977).

Vegetation types are not mapped routinely, but may be mapped for special projects. In the northeast coal area, for example, vegetation types of Tumbler Ridge were mapped at 1:20,000. Map units were single vegetation types or composites of several vegetation types. In most cases, vegetation types at the lowest level of the hierarchy (Fig. 6) were used in mapping, but where floristically related vegetation types occurred together, a higher level of the hierarchy was used.

Interpretation of units Some interpretations of vegetation units are made routinely, and others are provided in response to specific requests from resource managers. For the northeast coal study area interpretations have been made at several levels in the biophysical hierarchy. For forest zones and subzones, general interpretations have been made for revegetation of disturbed sites, soil capability for agriculture and forestry, distribution of wildlife habitat, and recreational implications of vegetation patterns (Environment and Land Use Sub-Committee 1977). For biophysical soil groups, vegetation input was used to determine forestry capabilities and identify options for tree planting; general wildlife interpretations were also made on

the basis of dominant browse species, common successional stage, rate of succession, and forage quantity (Vold et al. 1977). Interpretations that have been made for vegetation types at the proposed Tumbler Ridge townsite area include food species for ungulates, recreation carrying capacity, occurrence of attractive wildflowers and edible plants, visual density, and fire hazard (Block 1977, Resource Analysis Branch 1977a). Visual density assessments, though intended for recreation interpretations, could have applications for wildlife. Assessments were based on on-site measurements of the distance at which a person became hidden in a vegetation type, not on routinely collected vegetation data (Harcombe 1978).

In addition to interpretations for biophysical and vegetation units, a special classification and mapping system for vegetation sensitivity was developed. The map units were groups of present ecological condition units, classified according to broad similarities in the nature of sensitivity. The classification included units in which the vegetation itself is sensitive, such as alpine meadows, and units where present vegetation indicates some form of environmental sensitivity, such as high erosion potential. Sensitivity units were mapped at 1:100,000 for a major proposed transportation corridor in the northeast coal study area (Environment and Land Use Sub-Committee 1978).

Biophysical capability mapping for ungulates

Capability for ungulates is the ability of the land to support ungulate species on a sustained basis at a given level of management (Demarchi and Fuhr 1979). The wildlife capability methodology of the TSB evolved from the Canada Land Inventory (CLI) (Perret 1970), which was modified for application in British Columbia (Blower 1973). The current approach differs from the CLI system in several important ways (Demarchi and Fuhr 1979, Demarchi et al. 1981). The TSB capability units for wildlife are based on biophysical units

established through the mapping of terrain, soils, and vegetation; the CLI units were based on whatever data were available. The usual TSB scale of 1:50,000 permits more detailed mapping than did the CLI published scale of 1:250,000. The TSB provides a separate capability rating for each ungulate species present in each map unit, whereas CLI maps gave a combined rating for up to three major ungulate species. A TSB capability rating for a species is related to carrying capacity for that species. CLI capability ratings were based on biomass and expressed as white-tailed deer units (Blower 1973).

Land capability for ungulate production on Vancouver Island was mapped in the CLI program. The capability of land units to produce ungulates was rated on a 1-7 scale. Associated with each capability rating were limiting environmental factors, such as snowdepth or adverse topography, and the ungulate species considered in determining the rating. Since these maps were made, understanding of the ecology of the two ungulate species on Vancouver Island has changed. For this reason, and because the maps do not reflect current methodologies, they are not discussed here.

No further wildlife capability mapping has been carried out on Vancouver Island by the TSB. Wildlife capability studies have been completed for the northeast coal area (Resource Analysis Branch 1977b, 1979). Wildlife capability maps and reports for the East Kootenays and for the Smithers area are in preparation. The following discussion is based on Demarchi and Fuhr (1979), Demarchi et al. (1981), and on interviews with D. Demarchi, B. Pendergast, and B. Fuhr.

Methods Whenever possible, TSB wildlife staff are involved in the initial stages of the overall biophysical inventory. They participate in project planning, reconnaissance, and selection of areas for intensive sampling. In practice, this has not always occurrred, because preexisting soil maps have

been used in some projects. The actual capability mapping by the wildlife team is usually deferred until the other biophysical mapping has been completed.

The base for capability mapping is the set of terrain, soil and vegetation maps produced by the TSB, and the climate data provided by the Air Studies Branch. From these base mapping units, the classifier identifies areas of land judged to have different capabilities for ungulates, primarily on the basis of ability to provide food and cover. The main purpose of data collection is to identify these capabilities and the environmental conditions that determine them. Sources of information include published literature, government files, regional Fish and Wildlife Branch personnel and other knowledgeable persons, winter aerial surveys, and summer ground surveys.

In preparation for summer ground surveys, the study area is stratified on the basis of vegetation zones, mesoclimate, landforms, and soil associations. Sample sites are selected according to their apparent value to wildlife and their usefulness for determining capability class ratings. Initially, emphasis is on heavily used ranges, winter ranges, and areas that are near maximum capability in their present condition. Early seral stages are sampled heavily, as the maximum capability of a site for many ungulates occurs during early succession. Once the characteristics of the best sites have been determined, the classifiers also visit a variety of sites having lower capabilities.

Data collected in summer field work vary according to the requirements of local ungulate species and the expertise of the field crew. Percent canopy cover of all plant species (or sometimes of browse species only) is recorded by species and layer. The "utilization form class" of browse species is recorded (Walmsley *et al.* 1980). The standing crop of herbaceous material is estimated from samples that are clipped, dried, and weighed (Demarchi 1979).

In the office, each map unit is attributed a capability rating, a season of use, and a set of environmental conditions which affect its capability. At present, the relationship between the environment and the capability rating is subjective; it is based on the professional experience of the classifier. The TSB is currently developing a methodology that would make this inferential procedure more objective (B. Pendergast, pers. comm.).

Classification units Capability classes rate the ability of the land to support ungulates for long periods, assuming management practices that do not degrade the land. Capability assessments are based on the optimum native vegetation that can be maintained through prescribed burning, grazing, logging, or occasional slashing; or through protection from wildfire or land use practices that would reduce productivity for wildlife. Intensive management practices, such as fertilizaton or planting of forage species, are excluded. Thus, the capability classification is based on potential carrying capacity, and is independent of present seral stage.

Winter and summer ranges are distinguished. It is assumed that ungulate populations in British Columbia are limited by winter range and the seral condition of that range. The significance of the six capability classes used in the classification system is related to season of use. For winter ranges, each capability class has been assigned a range of carrying capacities for each ungulate species. The highest values for each species in the province, determined from the literature and through consultation with wildlife biologists, were assigned to Class 1. The carrying capacity of the other classes is a percentage of the carrying capacity of Class 1. For example, Class 1 and Class 2 blacktailed deer range have carrying capacities of 20-27 and 14-20 animals/km^2/yr respectively; Class 1 and Class 2 elk range have carrying capacities of 14-20 and 10-13 animals/km^2/yr. To provide for exceptionally high capabilities, Class 1 is sometimes subdivided into three superclasses.

Ratings for summer ranges are not based on the number of animals the area could support, as productivity of summer range is not considered directly related to population levels. Summer range classification is based primarily on species behaviour and habitat preference, and should be used as a relative measure of habitat value.

Capability ratings reflect only biological and physical parameters as they affect the wildlife species in question. They do not take into account social or economic factors or other land uses, except where these land uses have permanently altered the capability of the land. Nor do they account for the needs of other wildlife species; thus, the capability ratings for two species for the same area may assume two incompatible management regimes.

Mapping Biophysical capability for ungulates has normally been mapped at 1:50,000 by the TSB, though some 1:250,000 mapping is now being done. At 1:50,000, minor inclusions of other types are common. In some cases, the diversity that results from a complex landscape may itself be a factor in assessing wildlife capability.

Boundaries of capability map units follow biophysical map units established by other disciplines, most frequently soil boundaries. As the classifier only recognizes those biophysical boundaries that have ecological significance for ungulates, wildlife map units may be larger than other map units. Occasionally, the wildlife classifier may wish to recognize a boundary that was not recognized by other disciplines -- for example, a boundary between north- and south-facing slopes. Such a boundary is added in consultation with staff from the other disciplines.

The following information is given for each polygon: all ungulate species present; a capability rating for each species; a winter range/not winter range

designation; and environmental conditions which affect ungulate distribution and abundance. Environmental conditions relate to climate (e.g. deep snow, south-facing slopes), terrain (e.g. avalanche tracts, floodplain), soil (e.g. bedrock, organic soils), or human influence (e.g. urban development, reservoir draw-down zone).

Capability ratings for polygons are place-specific. Map units are evaluated on the basis of their position in the ecosystem as a whole. Thus, factors such as proximity of seasonal ranges and behavorial characteristics of the species are taken into account.

Special projects

At the request of resource agencies, the TSB undertakes special projects which vary in scope and objectives. In some cases, the major objectives have been related to wildlife. The mapping scale of these projects has ranged from 1:10,000 to 1:50,000.

One such special project was a study of the Lardeau Flats, in the West Kootenays. This study was conducted by staff from the soil and vegetation sections of the TSB; information about wildlife in the study area was provided mainly by Fish and Wildlife Branch personnel and local residents. The vegetation resources of the 20 km^2 area were described and mapped at a published scale of 1:10,000. Vegetation habitat classes and subclasses were characterized in terms of vegetation composition and structure, terrain, soils, and relief. Several parameters relevant to wildlife, including snow interception, shrub cover, herb cover, and seasonal food availability for ungulates, were rated for each subclass. Successional trends were described briefly. The importance of habitat units for waterfowl and ungulates was assessed, and management options suggested (Rafiq 1980).

One of the objectives of the study of Vold et al. (1980) was to assess the soil and vegetation resources of the Pend-d'Oreille Valley for input into a detailed wildlife management plan. The major concern was compensation for losses of whitetailed deer winter range due to a proposed B.C. Hydro dam. The wildlife portion of the study was carried out by a Fish and Wildlife Branch biologist. Soils and vegetation of the 220 km^2 study area were mapped on two mapsheets at a scale of 1:20,000. The vegetation classification was prepared by R. Ferster and based on a larger study, Vegetation Resources of the Nelson Area (82F) (van Barneveld, in prep.); methods were similar to those described above for the northeast coal vegetation study. Vegetation maps of the Pend-d'Oreille show biophysical forest regions, zones and subzones; vegetation types, usually in composite units; and macrophysiognomy (e.g. coniferous forested dense, pioneer shrub).

Two keys to vegetation types are presented. One of these is condensed from the hierarchical classification produced by COENOS. Its use requires a good understanding of plant taxonomy. The other key (Fig. 9) concentrates more on plant characteristics which are easily discerned by resource managers, and also incorporates a few environmental parameters.

Vegetation types are described. The major species and overall cover values are given for the tree canopy, advanced regeneration, and low shrub layers. Frequently occurring herbs are named. Vegetation types are further characterized by associated soil great group, surficial materials, elevation, aspect, and their successional stage, forest zone, and frequency of occurrence in the Pend-d'Oreille.

The Pend-d'Oreille report is a good example of the use of routine vegetation and soil data for wildlife interpetations. For each vegetation type, the following information is presented: % cover trees, % cover shrubs,

B.1.3. Artificial Key to Common Vegetation Types of the Pend-d'Oreille Valley

1a Trees are absent in the tree canopy. Strictly high elevation above 1800 m in elevation.
White-flowered rhododendron - alpine fir - Merten's cassiope - red mountain-heather (5) See page B19.

1b Trees are present in the tree canopy. If absent, then below 1800 m in elevation.

2a Rocky Mountain Douglas-fir and/or ponderosa pine are the only tree(s) present in the tree canopy.

Lead 2b on page B11

3a Willow species in the tall shrub layer are present. One or more of common juniper, arrow-leaved balsamroot or lance-leaved stonecrop are present, usually below 1150 m on rock outcrops or shallow dry soils on morainal materials or colluvium. Rocky Mountain maple, California filbert, Hooker's fairybells and white hawkweed are absent.
Rocky Mountain Douglas-fir - pine grass - western fescue complex (15) See page B21.

3b One or more of Rocky Mountain maple, California filbert, Hooker's fairybells or white hawkweed are present. Willow species in the tall shrub layer are absent. Common juniper, arrow-leaved balsamroot and lance-leaved stonecrop are absent.

4a California filbert in the tall shrub layer is present. One or more of Rocky Mountain maple, California filbert or mallow ninebark in the low shrub layer are present. One or more of Hooker's fairybells, blue wild rye grass or false Solomon's-seal are present. Types are usually found on south or west aspects below 1150 m. Redstem ceanothus in the tall shrub layer is absent. Common harebell is absent.
Rocky Mountain Douglas-fir - common snowberry - Hooker's fairybells - pine grass complex (13) See page B20.

4b Redstem ceanothus in the tall shrub layer is present. Common harebell is present. California filbert in the tall shrub layer is absent. Rocky Mountain maple, California filbert and mallow ninebark in the low shrub layer are absent. Hooker's fairybells, blue wild rye grass and false Solomon's-seal are absent. This type occurs more towards the eastern end of the valley.
Rocky Mountain Douglas-fir - common snowberry - pine grass - bluebunch wheat grass (11) See page B20.

2b Trees other than Rocky Mountain Douglas-fir and/or ponderosa pine in the tree canopy are present.

Fig. 9. Sample page of artificial key to vegetation types of the Pend-d'Oreille (Vold et al. 1980:B11)

% cover herbs, % cover and % chance of occurrence for each forage species (grouped by deer preference rating) in each layer (Table 7). A table of interpretations of vegetation types for deer habitat management provides: elevation range, aspect, rate of succession, snow interception by tree canopy (inferred from % cover of trees), shrub cover density (inferred from % cover of shrubs), presence of winter forage species, winter forage species potential, and interpretive comments (Table 8).

On the basis of soil and vegetation data, successional patterns of the Pend-d'Oreille were identified. Major successional trends and their relation to soils, aspect, and causal factors are presented in a table (Table 9). For each soil type the early seral, maturing seral, and climax vegetation types expected as a result of various causal factors (e.g. severe burn, repetitive burns, clearcut logging) are given. Successional sequences are distinguished by aspect where this is relevant. Important environmental characteristics (e.g. soil texture, moisture regime, growing season) are included. The user is cautioned that, because of the complexity of successional patterns, predictions about the results of particular site treatments must be made with discretion.

The Pine/Moberly studies in northeastern British Columbia (Harcombe et al. 1980, Thompson et al 1980, Fuhr 1980) focussed even more strongly on succession. This project was requested by the Fish and Wildlife Branch, and carried out by vegetation and wildlife staff of the TSB. The objectives of the vegetation study were to identify and map vegetation landscape units and stages of vegetation succession, and to infer vegetation response to removal of cover (Harcombe et al. 1980). The wildlife report interpreted soil, vegetation and wildlife information in support of a plan for protecting and managing wildlife habitat (Fuhr 1980). Biophysical capability mapping for ungulates, as described above, was also completed.

Vegetation Type

Western red cedar - Utah honeysuckle - western yew - blue-bead clintonia (20)

Number of Plot Samples/Type

7

Table B.2a: VEGETATION COVER OF THE PEND-D'OREILLE VALLEY FOR EACH VEGETATION TYPE

Cover Component	% Tree Cover		% Shrub Cover		% Herb Cover	
	Typical	Average	Typical	Average	Typical	Average
% Crown Cover	70	64	50	54	40	37

Table B.2b: WHITE-TAILED DEER WINTER FOOD PREFERENCE SPECIES OF THE PEND-D'OREILLE VALLEY FOR EACH VEGETATION TYPE

Species	Average Cover in Tree Layer	% Constancy (% chance of occurrence)	Average % Cover in Shrub Layer between 2-10 M	% Constancy (% chance of occurrence)	Average % Cover in Shrub Layer below 2 M	% Constancy (% chance of occurrence)	Average % Cover in Herb Layer	% Constancy (% chance of occurrence)
High Preference Species								
redstem ceanothus			1	14				
common saskatoon					1	71		
Oregon-grape					2	71		
western red cedar	15	57	25	100	8	100		
Rocky Mountain Douglas-fir	14	71	2	29				
blue grass spp								
bluebunch wheat grass								
Medium Preference Species								
willow spp			1	14				
rose spp					2	71		
American red blackberry								
Oregon boxwood					18	86		
kinnikinnick								
western red-osier dogwood								
Low Preference Species								
California filbert			1	14				
common paper birch	6	57	2	43				
grand fir	4	43	1	29	3	14		
creambush oceanspray								
Lewis' mock-orange								
ninebark								
red elderberry					1	14		
soopolallie								

Table 7. Excerpt from table showing cover and forage values for vegetation types (Vold et al. 1980:B56)

Vegetation Type	Elevation (m)	Aspect	Rate Of Succession	Snow Interception By Tree Canopy	Shrub Cover Density	Presence Of Winter Forage Species	Winter Forage Species Potential	Interpretations Of Vegetation Types For The Management For White-Tailed Deer Habitat
								timing may result in soil erosion and site destruction. Weed invasion can become a problem on disturbed sites.
Rocky Mountain Douglas-fir - pine grass - western fescue complex (15)	<1300	south	VS	L	M	M-VH	VH	These sites occur on steep south facing slopes with shallow soils or on rock outcrops. Insolation permits availability of browse in late fall and early spring. Marginal snowdepths require maintenance of canopy cover. Planting, widely-spaced Rocky Mountain Douglas-fir and/or ponderosa pine will reduce snowdepth. The abundance of browse species may be improved through seeding, planting, fertilizing or light spring burns. Short time moisture availability requires careful timing of treatments. Faulty timing will lead to soil erosion and site destruction. Weeds can become a problem on disturbed sites.
Western hemlock - devil's club - blue-bead clintonia - unifoliate-leaved foamflower (17)	650-1300	all aspects	R-N	H	H	L	L	Opening of the tree canopy will cause an increase in western red cedar regeneration and other browse species. The moss layer and decaying organic material should not be disturbed. The tree canopy must be maintained to reduce snowdepths in spring and fall. Proximity to creeks may provide watering opportunities. Hiding cover is important.
Western red cedar - Utah honeysuckle - western yew - blue-bead clintonia (20)	650-1500	all aspects	N	H	H	H	H	Opening of tree canopy will cause an increase in western red cedar regeneration and other browse species. The decaying organic materials of the forest floor are an important source of nutrients and should not be disturbed. Canopy cover must be maintained to reduce snowdepths.

Table 8. Excerpt from table showing interpretations of vegetation types for deer habitat management (Vold et al. 1980:B71)

SOIL TYPE	ASPECT	CAUSAL FACTOR	EARLY SERAL VEGETATION TYPES	HABITAT CHARACTERISTICS	MATURING SERAL VEGETATION TYPES	HABITAT CHARACTERISTICS	CLIMAX VEGETATION TYPES
F5 cont'd	All aspects	Lightburn or clear-cuts Selective logging cont'd			Western hemlock - devil's club - blue-bead clintonia - unifoliate - leaved foamflower (17)*	-on well drained materials -moderately mild to cool temperatures -on soils with rich organic layer	A climatic climax of western hemlock - western red cedar. Western hemlock - western yew - devil's club - oak fern (4)* Note: Seral western white pine, Rocky Mountain Douglas-fir, Engelmann spruce and alpine fir, which can occur in this vegetation type are absent.
					Western hemlock - western yew - devil's club - oak fern (4)*	-on well drained materials -moderately mild to cool temperatures -on deep soils with a rich organic layer	
L1		Severe burn	Lodgepole pine - soopolallie - western bracken - red-stemmed pipecleaner (38)*	-on fine textured materials -a drier environment than type (32)	Lodgepole pine - soopolallie - western bracken - red-stemmed pipecleaner (38)*	-on fine textured materials -a drier environment than type (32)	*A climatic climax of grand fir - western red cedar or western hemlock - western red cedar. Note: The regenerating species potential will determine the climax.*
		Lightburn or clear-cut Selective logging	Western larch - western red cedar - western thimbleberry - northern twinflower (32)*	-on fine textured materials -a wetter environment than type (38)	Western larch - western red cedar - western thimbleberry - northern twinflower (32)*	-on fine textured materials -a drier environment than type (20)	*A climatic climax of grand fir - western red cedar or western hemlock - western red cedar. Note: The regenerating species potential will determine the climax.*
					Western red cedar - Utah honeysuckle - western yew - blue-bead clintonia (20)*	-on fine textured materials -a wetter environment than type (32)	*A climatic climax of western hemlock - western red cedar. Engelmann spruce - western hemlock - cucumberroot twistedstalk - green-stemmed pipecleaner (2) Note: Seral lodgepole pine, Engelmann spruce and alpine fir, which can occur in this vegetation type are absent.*
					Engelmann spruce - western hemlock - cucumberroot twistedstalk - green-stemmed pipecleaner (2)	-on fine textured materials	
			Rocky Mountain Douglas-fir - common snowberry - Hooker's fairybells - mountain sweetcicely (26)*	-on fine textured materials -a dry environment	Rocky Mountain Douglas-fir - common snowberry - Hooker's fairybells - mountain sweetcicely (26)*	-on fine textured materials -a dry environment	*A climatic climax of grand fir - western red cedar. No climax stands were found during the study.*
C1	South	Severe burn	Rocky Mountain Douglas-fir - pine grass - western fescue complex (15)*	-south facing slopes -insolation -summer drought -on very shallow well drained soils	Rocky Mountain Douglas-fir - common snowberry - Hooker's fairybells - pine grass complex (13)*	-south facing slopes -insolation -summer drought -on well drained materials	An "edaphic" climax of Rocky Mountain Douglas-fir. Rocky Mountain Douglas-fir - common snowberry - Hooker's fairybells - pine grass complex (13)* Note: Seral lodgepole

Table 9. Excerpt from table showing major successional trends in the Pend-d'Oreille (Vold et al. 1980:B36).

The Pine/Moberly study area, which occupies portions of six mapsheets, was mapped at a scale of 1:50,000. Methods for collection of vegetation data were those described under Biophysical Vegetation Classification and Mapping. The computer program COENOS was used to define vegetation types from the 93 sample plots. These vegetation types were then integrated with existing information on soils and terrain to produce vegetation landscapes (A. Harcombe, pers. comm.). Vegetation landscapes represent areas of similar texture, drainage, or landform, over which similar trends in succession and climax vegetation occur. They are relatively homogeneous with respect to management alternatives and constraints. Associated with each vegetation landscape is a particular successional sequence. Stages of vegetation landscapes specify the successional condition to which the vegetation has developed; they are defined by plant community structure and plant competition relationships (Harcombe et al. 1980).

Map units for the Pine/Moberly study are vegetation regions, zones and subzones, vegetation landscapes, and vegetation stages. Composite units are used where two or three stages are so distributed that they cannot be mapped separately at 1:50,000. The relative proportions of the component stages are indicated, to the nearest 10%. Inclusions of 10% or less are ignored. An explanatory legend (Table 10) provides descriptions of vegetation landscape units and stages (Thompson et al. 1980).

For each of the twelve vegetation landscapes, successional patterns are described, and in some cases they are diagrammed (Fig. 10). Management options and constraints are discussed, as well as the consequences of certain management practices (Harcombe et al. 1980). Fuhr (1980) relates possible management practices to the needs of wildlife species, and identifies some specific opportunities for habitat enhancement through management.

7.2 Vegetation Landscape Units

Map label	Environmental Landscape Description	Vegetation[1] Dominants[2]	Associates[3]	Landform[4]	Soil Series[5]
AP trembling aspen - balsam poplar	Successional stages of trembling aspen and balsam poplar leading to a white spruce climax; occurs on fine to medium textured soils that are well to moderately well drained, generally, the soils have good moisture holding capacity and nutrient regime; usually occurring on plains and gentle slopes; tree canopy and understory are highly variable; widespread in study area.			fluvioglacial, lacustrine	Lynx (Ly) Codesa (Co) Beryl (By) Bramham (Br) Judah (Ju) Donnelly (Do) Widmark (Wi) Taylor (Ty)
AP1	Recent cleared areas that are being invaded by shrubs and herbs.	shrubs, herbs			
AP2	Pioneering vegetation of shrubs and herbs following fire; on moister sites willow is abundant.	trembling aspen, willow, balsam poplar, prickly rose, common fireweed, showy aster	small reed grass		
AP3	Young seral stands dominated by trembling aspen and balsam poplar; sparse regeneration of white spruce; stand density is a reflection of species establishment, competitive factors have not yet taken effect to impart structure to the community; dominant plants are growing as independent individuals.	trembling aspen, balsam poplar, willow, high bush cranberry, bluejoint small reed grass	white spruce, prickly rose		
AP4	Maturing seral stands dominated by trembling aspen with regenerating white spruce; plants are growing as members of a community and competition is in effect.	trembling aspen, balsam poplar, white spruce	red-osier dogwood, common paper birch		

Table 10. Excerpt from explanatory legend for the Pine-Moberly study area (Thompson et al. 1980:9).

5.1.9 TREMBLING ASPEN VEGETATION LANDSCAPE

The general successional pattern within the trembling aspen vegetation landscape is usually initiated by fire and leads from young seral stands of trembling aspen (TA3) through maturing seral stands of trembling aspen (TA4) to an expected white spruce climax (TA5). However, due to the historical frequency of wildfires, the climax is rarely reached in the study area. A very hot forest fire, or one that occurs shortly after (within about 20 years) a previous fire, may set the succession back to a pioneer seral stage (TA2) which may be dominated by willows

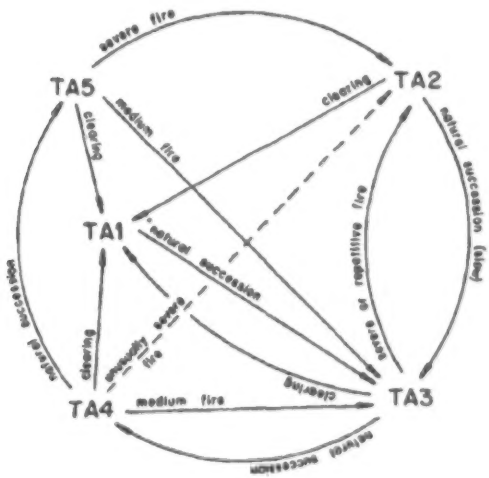

FIGURE 5.5 SUCCESSIONAL PATTERNS OF THE TREMBLING ASPEN VEGETATION LANDSCAPE

Fig. 10. Schematic diagram and partial description of successional patterns of a vegetation landscape (Harcombe et al. 1980:20).

At the request of the Fish and Wildlife Branch, the TSB is currently classifying and mapping the vegetation of the Salmon River floodplain on Vancouver Island. Vegetation landscapes and stages will be mapped at 1:20,000 in this area of approximately 3,250 ha (A. Harcombe, pers. comm.).

THE MOON-SELBY SYSTEM OF AGRICULTURE CANADA

This approach to soil and vegetation classification and mapping was begun in 1979 as a watershed-specific project by D. Moon and C. Selby of Agriculture Canada, Vancouver. The system represents the work of these individuals, not an approach officially adopted by Agriculture Canada.

The only classification conducted on Vancouver Island by Moon and Selby is a soil and vegetation study of the Power River, an unlogged watershed on the northwest coast of the island. This work was carried out in cooperation with and under contract to the Research and Planning Branches, Ministry of Forests, Vancouver Region. As the project is not yet complete, the following description is based on preliminary reports (Selby 1980, Moon and Selby 1981) and on interviews with Moon and Selby.

Objectives

The approach of Moon and Selby was developed to provide flexibility in data handling, classification, and interpretation. The specific objectives of the Power River project were to produce classification and mapping units that would be useful for making management interpretations with respect to a range of forest resources and activities. The soil classification was designed to be applicable to interpretations for engineering, slope and channel-bank stability, erosion potential, sediment yield, and flow velocity. The vegetation classification would permit interpretations for site preparation,

tree species selection, silviculture, and wildlife values. Both classifications would be applicable to interpretations for fishery values and for flooding.

Philosophy

The Moon-Selby approach to classification involves observing the similarities and dissimilarities present in a landscape, identifying recurring units, characterizing them, and mapping them. Moon and Selby emphasize the importance of an unbiased approach to the definition of units. No preconceived ideas of types are brought to the classification either at the sampling or the analysis stage. The guiding principle is to allow the data base to define the types.

Central to their approach is the concept that the classifier must deal with entire segments of the landscape, and not just with soil pits and vegetation plots chosen to represent typical conditions. The natural landscape is composed of repetitive patterns of soil and vegetation types, characterized by a similar relationship among types, and expected to be alike with respect to management opportunities and constraints. It is the job of the classifier to elucidate these variations, rather than to characterize model conditions.

There is an emphasis throughout on meeting the needs of the user - in this case, the forest manager. Attention is given to characterizing the units in such a way that a non-specialist can use and field-test the classification. The classification is intended to be useful for management, particularly by identifying those options and constraints that a manager must consider in a given unit, and eliminating those that are irrelevant.

Sampling

Sampling procedures were designed to minimize subjectivity in plot selection. For practical reasons, sampling was concentrated around areas suitable for helicopter fly camps. From these centres, transects were chosen to cross a variety of forest cover and landscape features. The field crew walked the transects and established plots as changes in soils or vegetation were encountered. Only sites meeting the following requirements were sampled:

a) minimum area 20x20 m
b) uniform vegetation physiognomy (life form structure)
c) a single species/area curve (homogeneity of species composition)
d) a single soil polypedon consistent in humus form and in thickness, and texture, and color of surface mineral horizon

Sampling and data analysis continued until treatment of the entire data base, as described below, produced no new vegetation or soil units. Data were analysed after 30, 45, 60 and 63 plots had been completed. Once the classifiers considered a unit well-defined, they did not sample it further; in the final stages sampling was limited to sites which did not fall within the limits of well replicated classes. Sixty additional soil and vegetation plots were added in which the data base was restricted to diagnostic characters. These were used to test the classification.

Thus, for a watershed of 8,100 ha, the classification was based on a sample of 63 full soil and vegetation plots and an additional 60 abbreviated plots.

Plots were approximately 20x20 m; their dimensions were estimated. The provincial site, vegetation, and soil description forms were completed, according to procedures described by Walmsley et al. (1980). The mensuration and wildlife data forms were not completed, but presence of browsing was recorded, by plant species.

Successional sites were sampled in the same manner as climax stands. As the Power River has not been logged or recently burned, successional sites were limited to recent floodplain deposits.

Analysis

Vegetation data were analyzed independently of soils data. The Ceska-Roemer program for identifying species-releve groups was used for vegetation analysis (Ceska and Roemer 1971, Mueller-Dombois and Ellenberg 1974:269). This program facilitates the sorting of vegetation data in a way similar to Braun-Blanquet tabular analysis. The main object of the program is to extract from the table those groups of species which best differentiate groups of plots. This is done by alternately applying two sets of rules. First, the computer is required to isolate a set of species that occur together in some plots and are mutually absent in others. Second, plots that include these diagnostic species are grouped. This process is continued until all diagnostic species are extracted. The classifier may specify how often diagnostic species must occur within the plot group and how often they may occur outside the plot group.

Once species groups have been identified, community types are defined on the basis of a diagnostic combination of species groups. The selection of species groups used to define the community types is based on their ability to differentiate groups of plots, and on their composition -- in this case, species groups containing easily identified species with high cover values were favored. The program produces a table which shows the relationships between species groups and community types, and among individual plots within community types.

Once community types were defined with the Ceska-Roemer program they were run on the program of Klinka and Phelps (n.d.), which requires that plot

groups be dictated. The complete tables provided by this program were used for descriptions of the structure and variability within community types.

Soils data were treated with a series of multivariate procedures. Factor analysis was used to determine major sources of variation and to identify potential classification parameters. Multiple stepwise discriminant analysis identified relationships between soils and plant community types. A cluster analysis was performed, based on variables which were of known interpretive value or which had been identified, through factor analysis, as carrying maximum accessory information. Soil characteristics which were predictable from the vegetation were not used. This soil classification, based largely on cluster analysis, was tested with an independent technique - multiple discriminant analysis - to ensure the relationships were valid. Through this sequence, a soil classification suitable for engineering interpretations was developed. For maximum information about the site, the soil classification must be used in combination with the vegetation classification.

A second soil classification was also developed, on the basis of variables identified in the discriminant analysis. This classification may be used to predict plant community types from soil properties.

Classification units

Vegetation Seven species groups were used to classify nine plant community types. Three regions within the watershed -- floodplain, upland, and high elevation -- were distinguished. A plant community could occur in more than one region.

Descriptions of community types (Fig. 11) include the following: the successional state (e.g. early succession, climatic climax, edaphic climax),

4. Tsuga-Tiarella type

This is the climax community type for both fluvial and upland areas in the Power River watershed. It is characterized by the presence of the Tiarella species group in conjunction with the Tsuga species group. The canopy is dominated by Tsuga heterophylla and Abies amabilis which are frequently joined by Picea sitchensis veterans on the floodplain. Picea occasionally occurs on upland soils as well - generally along channels or gullies. There is abundant regeneration of hemlock on both fluvial and upland units. Abies tends to be restricted to the A strata on fluvial stands but is common in the A and B strata of upland stands. The shrub layer is well developed. Vaccinium alaskaense and Vaccinium parvifolium are dominant. Rubus spectabilis is always present on fluvial stands but has a low species significance while Gaultheria shallon is generally present on upland units. There is a wide variety and abundance of herbs including the Tiarella species group, Blechnum spicant, and Polystichum munitum. Rhytidiadelphus loreus, Hylocomium splendens and Stokesiella oregana dominate the dense moss carpet.

The Tsuga-Tiarella type is very productive. Slopes are generally less than 40% and drainage is fairly good so that there is not an excess of water. Soils are well developed and have an LFH layer. The relatively high covers of Vaccinium suggest that this type is important for wildlife habitat.

A high elevation variant of this type contains Chamaecyparis and Tsuga mertensiana but otherwise the structure is virtually identical. The productivity might be slightly less than the low elevation type because of the shorter growing season and greater snowpack. The soils tend to have a higher organic matter content. This is one of the more productive high elevation types.

Fig. 11. Sample description of a Power River plant community (Selby 1980). Additional information on soil-vegetation units will be given in soil descriptions. Preliminary; used with permission.

the diagnostic combination of species groups, the dominant species in the tree, shrub, herb, and moss layers, and usually a general indication of the cover in each layer. General statements about forest productivity, slope, drainage, and soil development are often included. If rock outcrops occur frequently, that is mentioned. Comments on the abundance of browsing and of browse species are included for units in which browsing was evident. If there are major variations within the community type, these are described.

Two kinds of vegetation tables are provided. The summary tables of species groups and releve types present, for each community type, its component species groups, the number of sample plots, and the mean similarity of plots within the type. A synthesis table for each community type, in Ministry of Forests format, is also presented. These tables give, for each species in each layer, the mean presence (constancy), mean cover value, and range of cover values for all plots, and the cover value in each plot.

For on-site identification of community types, an allocation sheet is provided (Fig. 12). The allocation sheet lists diagnostic species for each species group, and specifies the minimum number of species in each species group that must be present for the species group to be considered present. The user ticks off all species occurring on the site, then all species groups, and finally identifies the community type from the diagnostic combination of species groups.

Soils Two soils classifications were developed -- one for making interpretations for engineering, and one for predicting vegetation communities. The engineering classification is the one that has abeen developed for presentation, mapping and interpretation. Seven diagnostic characters were used to define nineteen soil units. Descriptions of soil units, which are not yet available, will include the diagnostic characters, a

POWER RIVER SPECIES GROUPS:

SPECIES GROUP 1 3/6
Elymus hirsutis
Ranunculus uncinatus
Lactuca muralis
Alnus rubra (A1)
Carex canescens
Pleuropogon refractus

SPECIES GROUP 2 4/7
Tiarella laciniata
Tiarella trifoliata
Maianthemum dilatatum
Abies amabilis (B1)
Dryopteris austriaca
Athyrium filix-femina
Streptopus amplexifolius

SPECIES GROUP 3 3/6
Abies amabilis (A1)
Tsuga heterophylla (B1)
Vaccinium alaskaense
Gaultheria shallon
Rubus pedatus
Hylocomium splendens

SPECIES GROUP 4 2/3
Thuja plicata (A1)
Tsuga heterophylla (A3)
Thuja plicata (B1)

SPECIES GROUP 5 3/3
Chamaecyparis nootkatensis (A1)
Tsuga mertensiana (A1)
Tsuga mertensiana (B1)

SPECIES GROUP 6 6/9
Carex hoodii
Eriqeron peregrinus
Nephrophyllidium crista-galli
Drosera rotundifolia
Gentiana spp.
Tofieldia glutinosa
Eleocharis pauciflorus
Agrostis spp.
Eriophorum polystachion

COMMON SPECIES
Tsuga heterophylla
Picea sitchensis
Menziesia ferruginea
Rubus spectabilis
Vaccinium parvifolium
Blechnum spicant
Polystichum munitum
Coptis asplenifolia
Rhytidiadelphus loreus
Stokesiella oregana

WET INDICATORS
Adiantum pedatum
Carex obnupta
Lysichitum americanum
Oplopanax horridus

DISTURBANCE SPECIES
Stachys cooleyae
Circaea alpina
Galium triflorum
Leucolepis menziesii
Luzula parviflora
Melica subulata
Mnium glabrescens
Montia sibirica
Poa marcida
Tolmiea menziesii
Trisetum cernuum
Viola glabella

ADDITIONAL SPECIES

COMMUNITY TYPES

Species Groups Present	Type
1	Alnus-(Elymus)
1&2	Alnus-Tiarella
2	Tiarella
2&3	Tsuga-Tiarella
3	Tsuga-Gaultheria
3&4(+2)	Thuja-Gaultheria
3&5(+)	Chamaecyparis
6	Carex hoodii

Fig. 12. Allocation sheet for Power River vegetation (Selby 1980). Species Group 5 has been expanded and split in more recent version. Preliminary; used with permission.

number of accessory characters, and a discussion of the relationship between soil units and plant communities. The descriptions of soil units will also include interpretive information for the combined soil-vegetation units. A summary table including the means and ranges of diagnostic and accessory characters will be presented. A key to the soil units, for use with a soil pit, will be provided.

The importance of the second soil classification is its possible use in identifying the potential vegetation on logged sites. If its predictive value is confirmed, such a classification system would permit extrapolation of the results of management practices from previously logged sites to areas where logging is being planned.

Mapping

Soils and vegetation of the Power River watershed were mapped at a scale of 1:15,840.

Mapping began after the soil and vegetation classifications were complete. Probable boundaries were first identified on air photos, then checked on the ground. Compound map units were developed where fine-grained patterns were found, or where soil units or community types could not be detected on air photos. Once relationships between map units and air photo characteristics had been established, they were extrapolated to other areas.

Twenty-one soil map units and seventeen vegetation map units were defined. Soil map units were defined by a diagnostic combination of soil types, and vegetation map units by a diagnostic combination of community types. Some map units were dominated by a single soil or vegetation type; others were composed of two or more types in a repetitive pattern.

Descriptions of soil map units are presently in preparation. Each soil map unit will be described in terms of its component soil types. Interpretations for flood hazard and engineering, based on both soil and vegetation, will be included in the descriptions.

Each vegetation map unit is described in terms of its component community types, and its landscape characteristics -- the soil and site factors associated with the occurrence of community types (Fig. 13). Minor inclusions of other community types may also be mentioned, especially if they are expected to influence the use of the map unit.

Keys for the identificaion of soil map units and vegetation map units (Fig. 14) are provided. These were designed to be used from aircraft, and would require some modification to be used with air photos or on the ground.

On the final map, which is still in preparation, each polygon will be identified by its soil map unit and its vegetation map unit names. Boundaries appearing on the final map are those that were identified on air photos and in the field as corresponding to changes in soil, vegetation, or both.

Interpretation

A variety of hydrological, soil stability, and engineering interpretaions will be included in descriptions of soil and soil-vegetation units. Descriptions of vegetation units often include general remarks about use by wildlife. Units were designed to be useful for other interpretations as well, such as silvicultural prescriptions or wildlife management, but input from other professions would be required to actually produce these interpretations.

5. Vaccinium-Elymus (VE)
Definition of map unit:
The VE map unit is defined as containing the Tsuga-Tiarella community in complex with the subdominant Elymus-Tiarella type.

Landscape characteristics:
It occupies similar landscape positions to the Elymus (E) map unit but represents a more stable landscape segment, occupying somewhat raised river terraces on the floodplain. The presence of the Tsuga-Tiarella community indicates a long period of stability over the largest portion of the unit but the Elymus-Tiarella type indicates periodic localized disturbance. On the floodplain areas this disturbance is the result of infrequent flooding confined to well defined channels or topographic lows. The general lack of the Carex obnupta (sedge) and Lysichitum americanum (skunk cabbage) variants of the Elymus type and the presence of Amabilis fir indicates minimal periods of high water table levels. On debris flows or fluvial fans the presence of significant Elymus-Tiarella type indicates a relatively active system with periodic debris flows or migrating drainage lines.

The forest cover consists of Spruce, hemlock and amabilis fir with the anabilis fir often showing patchy distribution confined to better drained areas. The understory shows large areas of non-shrub vegetation dominated by grasses and swordfern within the dominant areas supporting a Vaccinium shrub cover.

Fig. 13. Sample description of a vegetation map unit of the Power River (Selby 1980). Preliminary; used with permission.

FIGURE 4: PROVISIONAL KEY TO VEGETATION MAP UNITS:

1. Floodplain units
   2a. Alder dominant; generally lacking Spruce and Hemlock..... E
   2b. Conifers present
      3a. Patchy forest cover
         4a. Alder with Spruce and Hemlock; grassy understory..... ET
         4b. Forested patches lacking Alder; openings with Elymus vegetation type..... TE
      3b. Uniformly even canopy (may be open); lacking Alder
         5a. Open canopy lacking Amabilis fir; high cover of Polystichum in herb strata..... T
         5b. Amabilis fir in canopy
            6a. Patchy Amabilis fir with a young understory (Elymus-Tisrella type); channeled..... VE
            6b. Closed canopy dominated by Hemlock and Amabilis fir with Spruce veterans; Vaccinium in understory..... V

1b. Upland units
   7a. Lacking Yellow cedar and Mountain hemlock
      8a. Forest cover having abundant Amabilis fir and lacking Red cedar; understory dominated by Vaccinium..... V
      8b. At least occasional Red cedar present or shrubs not dominated by Vaccinium.
         9a. Scattered Red cedar confined to the tops of steep rock outcrops
            10a. At least patches of open understory with generally high covers of Polystichum and Blechnum; on steep slopes
               11a. Lacking significant Salal..... P
               11b. Significant areas of Salal with patches of Polystichum..... GP
            10b. Understory dominated by shrubs (Vaccinium or Salal)
               12a. High Salal cover with patches of Red cedar (not in low slope positions)..... G
               12b. High Vaccinium cover with variable amounts of Red cedar; generally wet..... VC
         9b. Significant Red cedar - either patchy or an even cover throughout the unit
            13a. Understory dominated by Salal..... GC
            13b. Uniform cover of Red cedar in A and B strata; wet..... CT
   7b. Yellow cedar and/or Mountain hemlock present
      14a. Large patches of open sedge vegetation with minor shrub and forest areas..... S
      14b. Small areas of sedge
         15a. Forested with good productivity..... Y
         15b. Patchy forest cover with significant open areas
            16a. A lot of rock outcropping with heath vegetation; patches of yellow cedar and tall shrubs..... H
            16b. Dominated by Hemlock and Cladothamnus with patches of Empetrum and Yellow cedar..... M

Fig. 14. Key to vegetation map units of the Power River (Selby 1980). Preliminary; used with permission.

COMPARISON OF APPROACHES OF GOVERNMENT AGENCIES

Objectives

The three classification systems that have been described have substantially similar sets of objectives. The MOF aims for a classification to organize knowledge, and a classification to be applied as a tool for forest resource management. The TSB attempts to classify ecologically significant segments of the land surface, and to identify opportunities and constraints for management which take into consideration all resources. Moon and Selby have as their goal a classification which would be the basis for management interpretations for a variety of forest resources. In all cases the classification is intended to organize knowledge and to serve as a tool for resource managers. As part of their mandate to provide a management tool, all the classifiers attempt to identify classification units that will respond uniformly to management practices.

The mandate of the TSB is the broadest of the three, in that all terrestrial resources are to be considered. But in each case, the classification is to be a tool for the management of a variety of forest resources, including wildlife, and is not limited in application to wood production.

Because of its broad mandate, the TSB engages in a variety of classification and mapping projects. In the following section, only the activities of the vegetation staff are discussed, as they are most comparable to the activities of the MOF and of Moon and Selby.

Philosophy

The three systems differ in their origins and in their philosophical approaches. The MOF approach is a development of the work of Krajina (1965),

which integrated the zonal approach represented by Clements in North America, the phytocoenological approach of Braun-Blanquet, and the topological approach of Pogrebniak (Kojima and Krajina 1975). Krajina's work, though not oriented exclusively to forestry, emphasized ecology of forest trees and applications to silviculture (Krajina 1969). The vegetation classification of the TSB was also influenced by Krajina, but the overall approach evolved from the Canada Land Inventory and methodology of Lacate (1969). From this background, the TSB inherited an emphasis on mapping and on the application of land classification to resource planning. The Moon/Selby approach has also been influenced by Krajina's work; the analytical method applied to vegetation data is a computer adaptation of Braun-Blanquet tabular analysis.

The three approaches differ significantly in the relationship among disciplines. In the MOF, soils and vegetation, taken together, are the basis for classification of ecosystems; moisture regime, nutrient regime, and floristic composition are considered simultaneously during analysis. The TSB methodology draws on a number of disciplinary classification systems, selecting, at each level of the hierarchy, the most appropriate classification parameters. Communication among disciplines is an integral part of the process, intended to ensure that all eventually perceive the same ecologically significant units. In the Moon/Selby system, vegetation and soils data are analyzed separately, but are related through a soil classification developed to predict vegetation communities.

Philosophically, the classifiers differ in their concepts of the nature of classification. The MOF emphasizes the natural, taxonomic character of its classification system. Historically, the MOF approach developed from the Braun-Blanquet school, which viewed the classification of plant communities as analogous to the classification of organisms (Mueller-Dombois and Ellenberg 1974). The TSB does not emphasize the taxonomic nature of the biophysical

classification system, but rather its pragmatic value as a mechanism for organizing ecological information. Similarly, Moon and Selby emphasize meeting the needs of the user. Despite this difference in emphasis, the classification systems of all three agencies are natural rather than technical; all are multifactor classifications that were developed to serve a variety of purposes.

Only two of the three agencies have developed classification systems that are strongly hierarchical. The MOF and the TSB engage in classification at various levels of detail, which are accomodated by complex hierarchies. In contrast, Moon and Selby have so far applied their methods only in a detailed study of a small area, and have not developed a formal hierarchy.

Stratification and sampling

Methods of selecting areas for sampling differ significantly among the three approaches. In the MOF, sampling is stratified primarily on the basis of biogeoclimatic units and of soil moisture and nutrient regimes, as perceived in the field. The experienced fieldworker may have in mind concepts of modal ecosystem types which he brings to the process of site selection. In the TSB, sampling is stratified according to forest zonation, landform, and soil units. The Moon/Selby approach does not involve stratification; the classifiers put in samples along transects every time a change in vegetation or soil is observed.

For actual plot locations, all three agencies apply similar criteria of homogeneity with respect to vegetation and soils. Plot sizes are somewhat variable; Moon/Selby plots are usually about 400 m^2, MOF plots about 500 m^2, and TSB plots about 800 m^2.

Sampling intensity for zonal mapping could not be compared, because of differences in data base (e.g., use of preexisting studies) and mapping scales between the TSB and the MOF. However, all three classifiers have carried out large-scale (1:15,840 - 1:20,000) mapping projects. The TSB used 175 plots (19 full plots and 156 type key points) in the 22,000-ha Pend-d'Oreille Valley, or one per 126 ha. Sampling intensity of the MOF in the 6,000-ha Koprino watershed was similar: one plot per 118 ha. Moon and Selby sampled more intensively in the 8,100-ha Power watershed: they used 123 plots (63 full plots and 60 abbreviated plots), or one per 66 ha.

Methods for actual data collection are more or less uniform. All three agencies use standard data forms (Appendix 1) and the manual of Walmsley et al. (1980). Personnel from all three agencies were involved in the production of the manual. There are differences with respect to which items are recorded, among agencies and among projects within an agency. However, since all use the same data sheets, all are potentially able to collect the same kinds of information.

Analysis

Methods for analyzing data are completely different among the agencies. The MOF groups plots according to site characteristics, then refines the groupings on the basis of species composition. Professional judgment plays an important role in this procedure. In the future, the MOF plans to supplement these methods with numerical techniques. Numerical techniques -- dissimilarity analysis and cluster analysis -- are presently used by the TSB for vegetation analysis. Moon and Selby use numerical techniques for soil analysis, and computer-assisted tabular comparison for vegetation analysis. The professional judgment of the classifer plays a more restricted role in the TSB and in the Moon/Selby system.

Classification units

The classification units produced by the three systems are defined differently. At the zonal level, MOF biogeoclimatic units are defined by climatic variables and by zonal ecosystems. TSB forest zones are defined by the climax tree species occurring on similar soils and terrain. The climax forest is understood to reflect climate, but climate is not in itself a defining parameter. MOF subzones are defined by more specific climatic features and by zonal ecosystems at a lower biogeoclimatic level. TSB subzones are defined by successional tree species or by growth form of the tree canopy. Despite these significant conceptual differences, the similarities between the zones and subzones delineated by the two agencies are far more striking than the differences.

The relationship between the zones and subzones mapped by the two agencies on Vancouver Island is shown in Table 11. Units are arranged as they typically occur from the west side to the east side of the Island. The table is intended to indicate approximate geographical correspondence, and not a one-to-one equivalence between the two sets of units.

The most significant differences between the two classifications occur on the east side of Vancouver Island, where the MOF recognizes a Douglas-fir climax on zonal sites in the Nanaimo and Georgia Wetter and Drier Maritime Coastal Douglas-fir Variants (Klinka et al. 1979). The TSB acknowledges the present dominance of Douglas-fir in this geographical area, but identifies grand fir and/or western red cedar as the potential climax species in the Coastal grand fir - western red cedar zone, except on shallow-to-bedrock and south-facing sites. In the Coastal western hemlock - coast Douglas-fir subzone, the TSB considers western hemlock the potential climax species (Harcombe 1981).

Table 11. Biophysical and biogeoclimatic units of Vancouver Island, as mapped by two government agencies[1]

Terrestrial Studies Branch - Biophysical Forest Zones and Subzones (Harcombe 1981)	Ministry of Forests - Biogeoclimatic Variants (Klinka et al. 1980)
Outer Coastal Region	
Coastal western hemlock - western red cedar zone	not on Nootka-Nanaimo mapsheet
Coastal western hemlock - Pacific silver fir - western red cedar subzone	Estevan and West Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock Variants
Coastal western hemlock - Pacific silver fir - yellow cedar subzone	West Vancouver Island Montane Wetter Maritime Coastal Western Hemlock Variant
Subalpine mountain hemlock - Pacific silver fir zone	West Vancouver Island Maritime Forested and Parkland Mountain Hemlock Variants
Subalpine mountain hemlock - Pacific silver fir zone complex	West Vancouver Island Maritime Forester and Parkland Mountain Hemlock Variants and Coastal Alpine Tundra
Inner Coastal Region	
Subalpine mountain hemlock - Pacific silver fir zone complex	East Vancouver Island Maritime Forested and Parkland Mountain Hemlock Variants and Coastal Alpine Tundra

Table 11 - cont.

Inner Coastal Region - cont.	
Subalpine mountain hemlock - Pacific silver fir zone	East Vancouver Island Maritime Forested and Parkland Mountain Hemlock Variants
Coastal western hemlock - Pacific silver fir - yellow cedar subzone	East Vancouver Island Submontane Wetter Maritime Coastal Western Hemlock Variant and East Vancouver Island Montane Wetter Maritime Coastal Western Hemlock Variant
Coastal western hemlock - western hemlock subzone	East Vancouver Island Drier Maritime Coastal Western Hemlock Variant and West Vancouver Island Drier Maritime Coastal Western Hemlock Variant[2]
Coastal western hemlock - coast Douglas-fir subzone	Nanaimo and Georgia Wetter Maritime Coastal Douglas-fir Variant
Coastal grand fir - western red cedar zone	Nanaimo and Georgia Drier Maritime Coastal Douglas-fir Variant

1/ This table indicates approximate geographical correspondences between the two sets of units; it does not suggest that the units are equivalent. Adapted from a table prepared by L. Stordeur, Ministry of Forests, Vancouver.

2/ The West Vancouver Island Drier Maritime Coastal Western Hemlock Variant is located on central Vancouver Island in areas where high mountains oriented along valleys create rain shadows.

At lower levels, classification units are also defined differently. MOF biogeocoenotic units apply to ecosystems, and are defined by soil and vegetation characteristics. TSB units are biophysical, defined by soil and vegetation; or disciplinary, such as soil associations and vegetation types. The units of Moon and Selby are defined by vegetation and soil characteristics. The Moon/Selby system is essentially a component classification and the MOF system an integrated classification, whereas the TSB uses both kinds of unit.

Mapping

Mapping scales of the different agencies are diverse. The TSB does most routine mapping -- including forest zonation -- at a working scale of 1:50,000, though the presentation scale may be smaller. Special project scales range from 1:10,000 to 1:50,000. The MOF mapped central Vancouver Island at a scale of 1:500,000. Watershed treatment unit maps, such as the Koprino and the proposed Sayward Forest maps, are presented at 1:20,000. The Power watershed was mapped by Moon and Selby at 1:15,840. The use of 1:20,000 rather than 1:15,840 for many recent maps reflects the provincial government decision to adopt a limited number of metric scales for standard use, but according to Klinka et al. (1980), its suitability for forestry applications needs evaluation.

Mapping procedures of the MOF and the TSB are similar at the zonal level. Both agencies utilize existing ecological studies, ecological maps, and forest cover maps. Both agencies gather information for use in mapping concurrently with sampling for classification at a lower level. Both use transects as well as formal plots. The TSB takes into consideration soil association limits, which are mapped separately, in drawing zonal and subzonal boundaries. The MOF bases its boundaries on the occurrence of zonal ecosystems, edaphic

ecosystems, and characteristic combinations of species, wherever ground surveys were done. Elsewhere, boundaries are extrapolated according to elevation and topography.

Mapping procedures are also similar at lower hierarchical levels. In all cases, mapping follows classification. A key for the identification of units is prepared. All agencies use a combination of ground surveys and air photo interpretation. In the TSB, procedures vary according to the type of map unit, but mapping of vegetation types or biophysical units is typically done on a soil map base. Soil boundaries are used where appropriate, but vegetation boundaries from forest cover maps or air photos may also be used. Moon and Selby and the MOF rely mainly on air photo interpretation, with ground verification, for boundaries.

In mapping, the TSB and the MOF handle internal complexity of units in a similar way. Both agencies use composite map units where single map units are so distributed that they cannot be mapped separately. The TSB ordinarily ignores inclusions of 10%; inclusions of 20% or more result in composite map units. Some TSB maps indicate proportions of composite units to the nearest 10%. Similarly, MOF map units may contain up to 15% unnamed inclusions of other units; composite units are used for inclusions of more than 15%. Moon and Selby handle internal complexity by defining map units according to diagnostic combination of types. Thus, a vegetation map unit may be dominated by a single community type, or may be composed of two or more types. Landscape characteristics associated with repetitive patterns of types are discussed in the map unit descriptions. Minor inclusions of other types are mentioned in map unit descriptions if they are expected to influence local management.

Interpretation

The three agencies differ in the kinds of interpretive material provided in published reports. The TSB has produced a variety of interpretations for a

variety of classification units. A list of interpretations that are potential targets for TSB information was given by van Barneveld (1976). Examples of interpretations that are relevant to IWIFR interests are those of the Pend-d'Oreille study, which focussed on forested deer habitat, and the Pine-Moberly study, which concentrated on successional patterns. Moon and Selby, like the TSB, provide interpretations according to the objectives of the study. For the Power watershed, flood hazard and engineering interpretations were provided. Units were intended to be useful for other applications, but input from other disciplines would be required for the production of interpretations. The MOF produces interpretive classifications, in which taxonomic units are grouped into treatment units for management purposes. In the Koprino, the interpretive classification was intended for resource planning at the sub-unit level. Units were grouped according to ecological similarity and similarity of desirable forestry practices, and their forestry, wildlife, fisheries, and recreation values were identified.

OTHER CLASSIFICATION ACTIVITIES ON VANCOUVER ISLAND

Other classification activities on Vancouver Island have been carried out by forest companies and by government agencies.

In an effort to improve their knowledge of the productive capability and environmental limitations of the land base, Pacific Logging Company initiated a forest site mapping program in their 120,000 ha operating area. The classification is based on the concept of the total forest site -- the combination of all environmental features with which the forest land manager deals, including topography, bedrock, surficial material, climate, soil, flora and fauna. Following a compilation of existing maps and data, geology, soils, vegetation, and other forest resources were inventoried in the field. From

this information, biogeoclimatic subzones, biogeoclimatic variants, and production zones were defined and mapped. Production zones were delineated on the basis of environmental criteria, such as geology, climate, and topography, and of management criteria, such as site capability, species suitability, and equipment requirements. Selection of specific criteria depended on their importance in a given area. Forest management interpretations were then produced for each production zone (Korelus 1977).

MacMillan Bloedel Ltd. is developing an ecological classification program which has evolved from the biogeoclimatic scheme of Krajina (1965) and the habitat type classification of Daubenmire (1973; Daubenmire and Daubenmire 1968). The habitat type system is still in preparation, but some results from the biogeoclimatic program are available. In 1974, E. Packee of MacMillan Bloedel published a 1:240,000 map of the biogeoclimatic zones and subzones of Vancouver Island and adjacent areas. Biogeoclimatic units were described in an accompanying report (Packee 1974). One of the major applications of biogeoclimatic mapping has been the delineation of new seed provenance zones. Another application is the selection of tree species for planting. According to Toovey (1977), the MacMillan Bloedel approach to land classification emphasizes the need for economic input. Species selection guides, for example, take into account the economic value of tree species as well as ecological factors.

MacMillan Bloedel has also developed a system for rating winter range capability for blacktailed deer (Moir 1979, 1980). This system differs fundamentally from the capability classifications of the CLI and the TSB in that it is based on existing, rather than potential vegetation. A rating system incorporating slope, elevation, aspect, timber type, canopy closure, lichen cover, ground cover of browse species, and average height of browse species, was used to determine a numerical value for each area studied. Numerical values correspond to capability classes patterned after those of the CLI (Perret 1970).

British Columbia Forest Products has been active in ecological classification since 1971. Initially, their approach involved bedrock-soil maps and vegetation maps, produced by company personnel. The vegetation maps were based on the biogeoclimatic zones of Krajina, but the zones were subdivided and the units named after dominant tree species and minor vegetation species. The Nitinat Lake area of southwestern Vancouver Island was mapped in that way (Toovey 1977). Since that time, the approach of the company has changed, and methods presently in use do not differ significantly from those of the MOF (S. Spencer, pers. comm.).

Western Forest Products participated in the Koprino study of the MOF, and has engaged a consultant to prepare other ecological maps. Ecological mapping of a 12,000 ha area near Port McNeill is complete, and additional mapping on northern Vancouver Island is planned. The approach used is similar to that of the MOF (D. Rawlings, pers. comm.).

Canadian Forest Products has compiled maps of biogeoclimatic subzones for their operating area in the Nimpkish Valley. These maps, adapted from that of Packee (1974), were based on local knowledge and field checks. In the future, ecosystem and soils mapping may be carried out in sensitive watersheds (D. Lindsay, pers. comm.).

Of the other four forest companies operating on Vancouver Island, three use the classification system of the MOF and one has not yet conducted any ecological classification work.

The Pacific Forest Research Centre of the Canadian Forestry Service has had some involvement with classification projects on Vancouver Island. The Centre has carried out landscape analysis near Victoria and on the Gulf Islands (Senyk 1977), but as these projects are designed to aid land use

planning in urban fringe areas, they have little relevance to the IWIFR program. In the early seventies, the Centre participated with the CLI in a pilot project to develop methodology for land mapping in the coastal forest. A preliminary classification of the vegetation of the Nimpkish Valley was produced (Oswald 1972), but the project was discontinued shortly thereafter. Under an agreement with the province, the Centre has participated in soil mapping and some other classification activities of the TSB; this involvement terminated in 1980 (J. Senyk, pers. comm.).

Wildlife and vegetation classification has also taken place on Vancouver Island as part of overall development plans in special areas. The production of the Tsitika Watershed Integrated Resource Plan involved classification activities by a variety of participants, including federal and provincial government agencies, forest companies, and consultants (Tsitika Planning Committee 1978). Maps of forest cover, wildlife, fisheries, recreation, terrain, watershed ecosystems, land use, and a 6-year development plan were prepared at 1:31,680. Wildlife mapping, which was done by the Fish and Wildlife Branch, focussed on the identification of summer range for elk, and winter range for elk and deer.

The dominance of the MOF in classification activities on Vancouver Island is apparent. Outside government, most ecological classification has been carried out by forest companies, in close association with the MOF. Pacific Logging Company has developed a classification system suitable for forest management in their local operating area. MacMillan Bloedel is presently developing an independent approach which may prove applicable to wildlife over a broad geographic area, but the system cannot be evaluated at this time.

V. ASSESSMENT OF CLASSIFICATION SYSTEMS

Classification systems are ordinarily evaluated in terms of their success in meeting their own stated objectives. The task undertaken in this problem analysis is different: to assess, or recommend ways to assess, classification systems in terms of their ability to meet the needs of forest wildlife managers and researchers (Chapter III). Approaches that might be taken to a more general assessment will be discussed briefly.

This chapter covers only the three classification systems that have been discussed in detail: the ecosystem classification of the MOF, the biophysical classification of the TSB, and the soil-vegetation classification developed by Moon and Selby of Agriculture Canada. Except where the wildlife capability classification is discussed specifically, comments about the classification system of the TSB refer to biophysical vegetation classification or to special projects.

ASSESSMENT FOR WILDLIFE INTERPRETATIONS

General information needs

As a basis for research and as a tool for habitat management, the IWIFR program requires classification units that are homogeneous in their response to forest management treatments. As this criterion falls within the objectives of all three classifying agencies, it is reasonable to expect it of any of the classification systems. None has been evaluated for its success in producing homogeneous response units. An experimental design is required that would test for significant differences in responses to management within units for each classification system, and would test for significant differences in

uniformity of responses to management among systems. Responses to management would be measured by specific attributes, such as height of conifer regeneration, biomass of herbs, or cover of shrubs at a given time after treatment. In view of the investment that is presently being made in classification activities in forested areas, the importance of evaluating the success of classifiers in identifying homogeneous response units goes beyond the needs of the IWIFR program.

To evaluate the impacts of management practices on wildlife populations, and as a basis for preparing interpretive maps, the IWIFR program requires classification units that are as homogeneous as possible with respect to attributes that are important to wildlife. A list of such attributes for deer and elk is included in the following section. Classification systems are evaluated according to how well units are characterized by these attributes, but not according to the uniformity of attributes within units. A limited test of the correspondence between classification units and those attributes that are recorded by all agencies could probably be made from the original plot data. A more comprehensive evaluation would require collection of additional data in the field.

For any assessment of the correspondence between units and attributes, a distinction must be made between an evaluation of the classification system and an evaluation of the mapping system. A test of the classification system is based on data collected at the original plot locations. Such a test would require either relocation of original plots, which might not be feasible, or use of the original plot data. A test of the mapping system is based on data collected at sites randomly located within map units. Any evaluation of the mapping systems would have to take into account differences in the handling of internal complexity: the TSB and the MOF use composite map units, whereas Moon and Selby define map units by diagnostic combinations of vegetation or soil types.

Regardless of which classification system is adopted by the IWIFR program, modifications will probably be necessary. Units that are over-differentiated with respect to wildlife, or those that occur together in a predictable pattern, might best be treated as composite units, such as the land-types of Thomas (1979). Other units that are especially important for wildlife, such as wetlands, riparian areas, and avalanche tracts, are likely to require further differentiation. Some wide-ranging forested units may need to be subdivided on the basis of aspect, or other parameters that are significant to wildlife.

Some members of the TWG expressed the need for a capability classification. A capability classification could be based on the ecological classification that is selected for use in the IWIFR program. Alternatively, the TSB could be requested to develop wildlife capability maps for Vancouver Island. TSB wildlife biologists utilize base maps of terrain, soils, and vegetation, all of which are now available. However, the TWG should bear in mind that the capability classification used by the TSB wildlife staff is based on potential carrying capacity, and does not take into account the present seral stage of the vegetation. Such a classification is best suited to species for which the optimum winter range is a seral stage that can reasonably be achieved through management. It may require modifications to be useful in areas where the optimum winter range is old-growth, and little old-growth remains. As capability classifications are interpretive classifications which reflect current understanding, capability mapping might best be deferred until the end of the IWIFR program.

The IWIFR program requires a system that is flexible in the event of new information or changing management objectives. The three criteria for flexibility suggested in Chapter II are naturalness, low degree of information synthesis, and explicitness of classification parameters. All three

classification systems are natural, in that they are designed to be suitable for many purposes; their success in achieving that goal has not been evaluated objectively.

With respect to information synthesis, the three range from component to integrated levels. The Moon/Selby classification is essentially a component classification. Relationships between soil and vegetation are addressed, but these relationships are based on soil and vegetation units which are defined and described independently. The TSB classification includes both component units, such as terrain, soils, and vegetation types, and integrated units, such as biophysical types. The MOF classification system is an integrated one: vegetation and soil data are considered together in the definition of units.

The three agencies differ greatly in the explicitness of classification parameters. Two factors contributing to explicitness must be distinguished: adequate description of methods, and objectivity of methods. At present, no agency has produced complete and adequate descriptions of methods. Moon and Selby have not yet completed their reports on the Power River watershed, but the preliminary description of the vegetation methodology (Selby 1980) appears to be adequate. Neither the TSB nor the MOF has published satisfactory descriptions of methods, though both agencies intend to do so. Additional information concerning the methods of Krajina and his students may be obtained from theses and publications, such as Brooke et al. (1970), Wali and Krajina (1973), and Kojima and Krajina (1975). But these authors themselves rely rather heavily on references to earlier work, particularly in their descriptions of methods of data analysis. Furthermore, it is difficult to be sure how directly the descriptions of methods in these publications apply to the MOF.

Agencies also differ in their relative emphasis on objective methods and professional judgment. It is widely acknowledged that subjective methods can produce a good classification system, but classifications based on subjective methods are thought to be less adaptable than those that are more objective (Bailey et al. 1978). In the MOF system, professional judgment is important at the sampling and at the analysis stage, though present methods will be supplemented by objective methods in the future. The professional judgment of the classifier also has a role in the TSB and the Moon/Selby systems, but it is more restricted. Both have attempted to minimize subjectivity in plot selection -- the TSB by prestratifying to reduce sampling choice to fairly narrow limits, and Moon and Selby by applying explicit rules for plot selection along transects.

The IWIFR program requires a classification system that can be applied to large-scale mapping anywhere on the island. All three agencies are capable of producing large scale maps, and utilize methods which are applicable anywhere on the island. As a result of their subzone mapping activities, the TSB and the MOF already have a data base for the definition of vegetation types and biogeocoenotic associations, respectively, over much of the island.

A classification system to be used by the IWIFR program must deal with internal complexity in a way that is relevant to wildlife. The MOF and the TSB, in large scale mapping projects, handle internal complexity by mapping composite units. Up to 15% unnamed inclusions may be present within a polygon. This approach provides a limited amount of information about diversity. Moon and Selby define each map unit in terms of a diagnostic combination of plant community types or soil types. In the descriptions of map units, the characteristic recurring patterns of these types are discussed, and related to landscape characteristics. These descriptions appear to be more useful in judging the diversity of the unit than are composite map

units. The application of any map for wildlife interpretations would be improved by the inclusion of special features: rock outcrops, wetlands, and water.

The IWIFR program requires a classification system that provides a framework for describing the floristic and structural characteristics of seral stages, as well as of potential vegetation. They need maps which show existing vegetation, and the information which will allow them to predict changes in vegetation over time, according to various management scenarios. Of the three agencies, only the TSB has completed projects that focussed on successional patterns. The Pend-d'Oreille report (Vold et al. 1980) presents, for each soil type, the early seral, maturing seral, and climax vegetation types expected as a result of various disturbances (Fig. 9). The Pine-Moberly reports (Harcombe et al. 1980, Thompson et al. 1980) identify vegetation landscape units -- areas of similar texture, drainage, or landform over which similar successional trends occur -- and a sequence of successional stages associated with each unit. For each vegetation landscape unit, the successional pathways that may be expected as a result of various causal factors are presented (Fig. 10). Map units are identified with symbols that indicate both the vegetation landscape unit and the stage. Descriptions of vegetation characteristics of each stage (Table 10) provide information about existing vegetation, and descriptions of successional pathways allow the prediction of vegetation changes under various management scenarios. Although the actual predictive success of the system has not been evaluated, the concept appears to address the needs expressed by the TWG.

The MOF is currently doing fieldwork in the Sayward Forest which will result in a classification that includes successional stages. Methods of stratification, sampling, and analysis are similar to those used in studies of climax vegetation, except that numerical techniques will be used as

supplementary analytical tools (R. Green, pers. comm.). Additional data relevant to wildlife use, including shrub density and height, browse utilization, pellet group counts, and bird surveys, are being collected concurrently. These data are intended mainly for use in developing treatment units for deer management (B. Nyberg, pers. comm.). The Sayward studies are not yet far enough advanced to be evaluated here.

Moon and Selby have not classified any areas where secondary succession is taking place. However the soil classification for predicting vegetation that Moon developed in the Power River has potential application to successional studies. If the soil classification can be used to predict climax vegetation of an area that is presently in an early seral stage, then it is a powerful tool for use in studying succession, and in making predictions about the consequences of forest management practices.

Some members of the TWG emphasized that it is important to be able to identify units on the ground. All three agencies have provided tools, in addition to maps, for use in the identification of units. Some of these are intended only for use by specialists (Fig.8), but most may be used by persons with more limited training (Figs. 3, 4, 5, 9, 12, 14). Their success as identification tools would be best evaluated through field trials.

Specific information needs

To be useful to wildlife biologists, units must be reasonably homogeneous with respect to attributes important to wildlife, and they must be characterized in terms of these attributes. Homogeneity of classification units cannot be assessed without detailed studies, but it is possible to assess the extent to which relevant data elements are recorded and are included in the characterization of units.

In Table 12, the list of data elements proposed by members of the TWG as a basis for interpreting habitat components for deer and elk (Chapter III) is reproduced. As discussed earlier, more work is needed to identify the data elements that are most appropriate for making such inferences. Many of the data elements that are listed correspond to parameters on the data sheets that are used by all three agencies (Appendix 1); those that do not are rarely recorded. The table shows which of these data elements are ordinarily collected by the three agencies, and which were reflected in the characterization of classification units in three detailed studies. The Pend-d'Oreille study of the TSB was selected because it was oriented to interpretations for white-tailed deer habitat; items that were used to characterize units in the Pend-d'Oreille are not necessarily used in other TSB projects.

The data elements pertaining to physical features are routinely recorded by all agencies, but there is variation in the manner in which they are used to characterize units. For the purposes of wildlife biologists, general descriptions of slope and aspect are probably adequate, but the elevational range of the unit should be given quantitatively. Descriptions of relief should include micro- as well as macrotopography. The schematic diagrams as well as the descriptions in the Koprino report (Fig. 2) are especially helpful in presenting relief. Only Moon and Selby regularly mentioned occurrence of rock outcrops in units where they were frequent. Except for a few units for which proximity of water is obvious, distance to water is place-specific, and is best interpreted from a map.

Of the three agencies, the MOF collected the most data elements pertaining to the overstory, and Moon and Selby the fewest. There was considerable variation in the data elements that were reported. Only tree species were reported by all three. Crown closure, an important data element for the

Table 12. Data elements relevant to deer and elk used in the characterization of classification units.

DATA ELEMENT	DATA SOURCE[1]	CLASSIFICATION UNITS[2] Biogeocoenotic associations Koprino watershed[3]	Vegetation types Pend-d'Oreille Valley	Plant communities Power watershed
Physical features				
Slope	S-10, T	R Q	R	R G
Elevation	S-11, T	R Q	R Q	R G
Aspect	S- 9, T	R G	R G	R
Relief	S-12,19-22, 25	R G	R	R G
Rock outcrops	S-43	R	R	R G
Distance to water	T			
Overstory				
Tree height	V, M	R	R	R
Crown closure	V	R Q	R G Q	R
Stand age	M	R	(R) G	G
Tree species	V, M	R G	R G	R G
Patchiness of canopy	V	R	R	
Stems/ha	M	R		
Average basal area/stem	M	R		
Crown length	-			
Understory				
Biomass or surrogate by layer	V	R Q	R G Q	R G
by species	V	G	R	R G
by species and layer	V	R	R Q[6]	R Q

Table 12 (cont.)

Understory (cont.)					
Distribution by species and layer	V	R	R	R	
Visual density by layer	-				
Crown length of forage species	-				
Stem density of forage shrubs	-				
Browse utilization by species				R[7]	C
% of plants showing signs of browsing	V[8]	R	(R)		
average % of each plant browsed	V[8]	R	(R)		
distribution of browsing					
Other					
Abundance of arboreal forage lichens	V[8]	(R)	(R)		
Obstructive debris	-				
Interspersion with other units	-				C

Table 12. (cont.)

Notes

1. See Appendix 1
   S - Site Description Form
   V - Vegetation Description Form
   M - Mensuration Form
   T - Topographic maps

2. R - data element recorded, or computable from recorded information
   (R) - data element recorded in some projects
   G - general information included in descriptions of units (e.g. crown closure high)
   Q - quantitive information included in descriptions (e.g. crown closure 70 - 90%)

3. Klinka et al. 1980; F. Nuszdorfer pers. comm.

4. Vold et al. 1980; A. Harcombe pers. comm. Information on data recorded refers to general practice of the TSB, not to the Pend-d'Oreille study.

5. Selby 1980; C. Selby pers. comm.

6. Forage species only.

7. Presence of browse only; no quantitive estimates.

8. The blank spaces on the right side of the vegetation data sheet are often used for this purpose.

interpretation of snow interception, was given by only two of the three agencies. The patchiness of the canopy can be inferred if a distribution class (Walmsley et al. 1980:136-137) is assigned to the tree canopy, but this is not always done. Stems/ha and basal area/stem may be calculated if mensuration data are collected. Crown length is not included on the data form, but is relatively easy to determine in the field. Canopy measures related to snow interception should be reviewed before any recommendations are made to classifiers about changes in data elements.

All agencies recorded percent cover and distribution class of understory species by layer: herbs, tall shrubs (woody plants 2 - 10 m high), and low shrubs (woody plants less than 2 m high). Overall percent cover of each layer was also recorded consistently. This information was presented in a variety of formats.

Wildlife biologists require data elements from which they can interpret how effectively the shrub layer hides animals. A measure of visual density is a good data element for this purpose, but is not ordinarily included in general-purpose inventories. Percent cover of shrubs, by layer, is often used as a surrogate. This information is required in a quantitative form, as in the Koprino and Pend-d'Oreille reports. The range, as well as the mean, would be helpful.

Wildlife biologists need quantitive information about available forage species, by layer. Percent cover is the only surrogate for biomass that is included on the data sheets. Ecological descriptions of units are usually inadequate for the wildlife biologist, because the classifer does not distinguish between forage and non-forage species. The wildlife biologist must consult vegetation tables, such as those included in the Power River report, to assess forage abundance in the unit. As these tables are lengthy

and technical, they are often left out of published reports. Tables such as those in the Pend-d'Oreille report (Table 7) are found only in studies oriented especially to wildlife. Descriptions of units in general ecological studies would benefit wildlife biologists more if the classifiers either determined the major forage species and presented cover values for those species, or presented cover values for the most abundant species in the low shrub and herb layers. For the wildlife biologist, information about abundant species is more important than information about indicator species.

Often, the wildlife biologist is unable to tell the classifer which forage species are most important in a given watershed. Utilization of forage species by ungulates may vary greatly from one part of Vancouver Island to another, as is evident from a comparison of the food habits of black-tailed deer reported by Cowan (1945), Gates (1968), Jones (1875), and Rochelle (1980). Information collected by classifiers on browse utilization can aid not only in assessing current use, but also in determining which forage species are locally important. Though quantitative browse data are often collected, they are not always included in characterization of units. Moon and Selby noted only species and not amounts browsed, but included comments on browsing in the descriptions of units.

Abundance of arboreal forage lichens is sometimes recorded, along with other epiphytes, by the MOF and the TSB. It was not included in the characterization of units in either the Pend-d'Orelle or the Koprino, though arboreal lichens are probably used as forage by ungulates in both areas. Data on obstructive debris were not collected, and are probably more important in studies of the responses of units to forestry practices.

Interspersion with other units is not a plot-specific data element, but must be judged from ground transects and air photos. Selby's discussion of recurring patterns of plant communities within map units is helpful in assessing habitat diversity for wildlife.

The data elements relevant to wildlife that are recorded by the three agencies are similar in most respects. As all use the same data forms and manual, all are potentially capable of collecting the same set of data elements. There is more variation in the manner in which the classifiers use these data elements to characterize classification units. No particular presentation emerges as consistently superior to the others; each has strengths and weaknesses with respect to its usefulness in making wildlife interpretations.

It is also relevant to ask whether data that are recorded but not presented are retrievable, as such data are potentially useful in establishing relationships between attributes and units. The MOF and the TSB plan to use provincial soil and vegetation data banks, but these are not yet operational. At present, TSB floristic data, but not physical or soils data, are computer-retrievable. The vegetation and soil data of Moon and Selby are to be entered into a federal soil data bank (CanSIS), if project approval is received. They are currently on file at the University of British Columbia Computing Centre, and are available through Moon or Selby. Thus, the data of all agencies are expected to be computer-retrievable eventually, but not all are at the present time. Other data are manually retrievable from the original data sheets.

APPROACHES TO A GENERAL ASSESSMENT

In the foregoing section, three classification systems used by government agencies were discussed in terms of their ability to meet the needs of forest wildlife managers and researchers. To a considerable extent, the success of systems in meeting the needs of the IWIFR program depends on their ability to meet criteria that are of interest to most users of the systems, not just

wildlife biologists. For example, the ability of the systems to identify units that respond homogeneously to forest management activities is of general interest.

Large investments are currently being made in classification of forest land in British Columbia. Land classification systems which are to be used as a basis for management should be professionally credible (Davis and Henderson 1978, Nelson et al. 1978). To be professionally credible, systems must be conceptually accepted by peer review, capable of objective validation, and preferably, validated (Davis and Henderson 1978). The purpose of this section is to suggest some criteria that might be used in validation. One of the major difficulties in carrying out such a task would be identifying criteria which would be acceptable to all concerned. The following criteria are presented as a basis for discussion.

How well does the system succeed in meeting its own objectives? To the extent to which classifiers are able to define precise objectives for their classifications, they should by all means be used as a basis for evaluation. The specific criteria for success should also be defined by the classifiers.

Are the classification units homogeneous in their response to forest management practices? This objective is implicit in the stated goals of the classification systems that have been discussed.

Are the language and logic of the system understandable to the non-specialist? Forest managers spend considerable time explaining their expectations and justifying their actions to people who are concerned, but may not be technically expert. A classification system having a simple, common-sense logic and vocabulary is a superior communication device for this purpose (Davis and Henderson 1978).

Can the classification units be readily identified by field staff? One of the functions of a classification system is to assist in the transfer of experience gained elsewhere to a site under consideration for management. To use the classification system as a tool, field staff must be able to recognize the units. Ideally, a classification should provide several options by which places can be identified, depending on the skills and resources that are available (Davis and Henderson 1978).

Is the system flexible enough to adapt to changes in ecological understanding or in management objectives? This criterion is as important to land managers in general as to wildlife biologists.

Is the system cost-efficient? This criterion is of obvious importance, but is not easy to assess. The cost of applying a system should be weighed against its benefits, some of which -- such as the value of having information about a climax vegetation community that no longer exists in climax state -- are intangible and are realized over a long time period. However, it is possible to compare the efficiency of various systems in classifying at a similar level of detail, taking into account such factors as field time, field costs, expertise required of personnel, office time, and computing costs.

Is the classification based on a large number of attributes? This criterion is commonly cited as a desirable characteristic of a natural, multi-purpose classification system (Mueller-Dombois and Ellenberg 1974:155, Sokol 1974), but not all classifiers agree (Williams 1967). Most classifiers do agree that it is important to seek stability in a classification system (Macnaughton-Smith 1965, Williams 1967). Some attributes, such as ones that are controlled to a significant extent by factors extrinsic to the site, or ones that are variable over short time periods, are likely to detract from the stability of a classification (J. P. Kimmins, pers. comm.). The desirability

of necessarily using large numbers of attributes is unclear, and it is unlikely that classifiers in British Columbia would agree on this as a criterion.

The criterion of stability, mentioned above, is the one most often used as an internal criterion of a "good" classification. It may be rephrased by posing the question: does the classification allow us to make powerful and valid inferences about the larger population of which the data are a sample? The larger population may consist of either individuals (plots) or of attributes (Macnaughton-Smith 1965). Stability may be tested by questions such as the following: If the same data are collected from additional plots, can these plots be fitted into the existing classification system with little alteration? Are the units good predictors of other attributes which were not included in the original classification? Some of the evaluative criteria which have already been suggested, such as relationships between units and attributes that are important to wildlife, are tests of stability.

Is the classification repeatable by other scientists? Theoretically, any scientific procedure, when repeated, should give similar results; one could argue that if classification is a scientific procedure, then other scientists should be able to replicate it. However, the importance of judgment in classification is widely acknowledged (Williams 1967, Bailey et al. 1978, Pfister and Arno 1980), and it is not reasonable to expect two scientists using the same methods to produce identical classifications. It is reasonable to expect a general correspondence between results when different methods are applied to the same data (J.P. Kimmins, pers. comm.), but this would be difficult to apply as an evaluative criterion.

This set of possible criteria to be considered in evaluating classification systems is neither exhaustive nor final, but is presented here as a stimulus to thought.

VI. CONCLUSIONS

This problem analysis was originally envisioned as an evaluation of existing classification systems strictly in terms of their ability to meet the specialized needs of the IWIFR program. As the classification systems were developed to meet different, broader, objectives, such an undertaking was thought to be quite different from an overall evaluation of classification systems.

The needs of the IWIFR program were determined through interviews with members of the TWG. Three classification systems were selected for detailed study -- the ecosystem classification program of the MOF, the parts of the biophysical classification system of the TSB that deal with vegetation and wildlife, and the soil-vegetation classification of Moon and Selby of Agriculture Canada.

One of the problems encountered in preparing descriptions of the classification activities of these government agencies was the lack of published descriptions of methods. At present, not one of the three has made available comprehensive descriptions of methods. The activities and methods of the agencies are poorly understood outside the agencies themselves. Review of scientific work by other professionals is impossible when methods are not understood. The need to prepare explicit, comprehensive descriptions of methods cannot be overemphasized.

Some of the information needs expressed by members of the TWG are special requirements of wildlife biologists. Some information commonly collected by classifiers is important for making wildlife interpretations, but is often left out of descriptions of units: landform and relief (including

microtopography), presence of rock outcrops, crown closure, overall cover of the shrub layers, cover of the dominant understory species (not just indicator species), browse utilization, and abundance of arboreal forage lichens. Other data elements not commonly collected by classifiers were also proposed by wildlife biologists, but in many cases, it was not clear which data elements correspond best with wildlife habitat components. Wildlife biologists need to review and improve the list of data elements needed for making interpretations about habitat components. Some classifiers expressed willingness to try to meet the needs of wildlife biologists, but complained that they have not received clear statements of what these needs are. Once wildlife biologists have identified their information needs, they should meet with classifiers to develop feasible techniques for measuring or recording the appropriate data elements at an inventory level.

The classification systems studied are substantially similar in the relevant data elements that they collect. None is clearly superior in the way units are characterized. Potentially, all can collect the same data, and can respond to requests from wildlife biologists for changes in characterization of units.

Wildlife biologists typically require classifications and maps that deal with existing vegetation, not just climax vegetation. The IWIFR program requires a classification framework that will permit the prediction of the floristic and structural characteristics of seral stages developing after forest management activities. Such a framework would require much information that is not presently available. All three agencies have contributed or are contributing to the study of succession. The MOF is currently developing a classification for seral stages in the Sayward Forest. The soil classification for predicting potential vegetation, developed by D. Moon in the Power watershed, should be tested in logged stands. The successional model developed by the TSB for the Pine-Moberly area appears to be the kind of framework that addresses the needs of the IWIFR program.

Some of the needs of the IWIFR program are the same as, or are special cases of, the needs of other users of classification systems. The need for units that respond uniformly to forest management practices and the need for a system that is adaptable to changing knowledge and management objectives, are common to nearly all users of the classification systems. The need for classification units that correspond reasonably well to attributes important to wildlife is a special need of wildlife biologists, but predictive value for attributes that were not classification parameters is a desirable characteristic of any general-purpose classification system.

The success of classification systems in meeting most of these more general needs could not be evaluated here, because of lack of information. Adaptability is believed to be greater in those classification systems that use objective, precisely defined classification parameters. Professional judgment has an important role in all classifications, and good classifications can be produced by largely subjective processes. However, methods such as those presently used by the MOF that rely heavily on professional judgment, are less easily modified or adapted to new purposes because the basis for classification is less explicit.

It has not been possible, in this problem analysis, to arrive at a recommendation for the IWIFR program to adopt any one classification system. Those few criteria which could be applied do not form an adequate basis for a decision. With respect to some criteria, the systems do not differ significantly. Most of the criteria proposed here require field studies for evaluation. Furthermore, the selection of any system by the IWIFR program will take into account political considerations which are outside the scope of this problem analysis. Regardless of which classification system is selected, modifications will be required.

The need to evaluate classification systems currently in use goes beyond the requirements or the mandate of the IWIFR. The classification of forest land is expensive and is important. There is currently duplication of effort among agencies. Each classification system serves some purposes better than others, and each could be improved by evaluation. An evaluation program is recommended, not in order to select one system and eliminate others, but to identify the strengths and weaknesses of each, and to improve each through feedback. General evaluative information would facilitate the selection of a system by special-purpose users such as the IWIFR program.

GLOSSARY

This glossary provides definitions for terms as they are used in this report; they may be used differently by other writers.

The number of the page on which the term is introduced follows the definition.

biogeoclimatic phase -- See p. 41.

biogeoclimatic subzone -- See p. 41.

biogeoclimatic variant -- See p. 41.

biogeoclimatic zone -- See p. 41.

biogeocoenotic association -- See p. 41.

biogeocoenotic type -- See p. 41.

biogeocoenotic variant -- See p. 41.

biophysical forest region -- See p. 58.

biophysical forest section -- See p. 58.

biophysical forest subzone -- See p. 58.

biophysical forest zone -- See p. 58.

biophysical forest type -- See p. 58.

biophysical unit -- An ecologically significant unit defined on the basis of biological and physical parameters (p. 57).

capability classification -- A technical classification of land into units that are uniform in their potential ability to support a particular use, such as wildlife production or forestry (p. 21).

classification system -- A system produced by arranging objects into groups on the basis of their similarities or relationships, so that general statements can be made about the groups (p. 3).

climatic climax -- A plant community that is in equilibrium with its environment and that is predominantly controlled by the regional climate (p. 36).

cluster analysis -- Any of a number of computer-derived classification techniques used to group plots, species, or other classification parameters together so that the groups are relatively homogeneous, as expressed by a similarity coefficient (p. 56).

component classification system -- A set of classifications of the biophysical components of the landscape, such as bedrock, soil, and potential vegetation, which are classified separately (p. 4).

constancy (presence) -- Frequency of occurrence of a species in plots of a given classification unit, usually expressed as a percentage or as a class defined by a range of percentages (p. 57).

data element -- An objective descriptor or measurement of habitat (e.g. stems/ha, % cover shrubs) that may be used as a basis for interpreting habitat components (p. 25).

discriminant analysis -- An analytical technique used to identify the independent variables which contribute most to the linear functions which differentiate among classification units (p. 87).

dissimilarity analysis -- A method of analyzing vegetation data in which a set of plots is repeatedly divided into subsets which are maximally different from one another in species composition (p. 56).

distribution class -- One of nine classes used for describing the spatial pattern of plant species in a vegetation plot, e.g. "a few sporadically occurring individuals"; "several well-spaced patches or clumps" (p. 56).

edaphic climax -- A plant community that is in equilibrium with its environment and that reflects site influences more strongly than the influence of the regional climate (p. 36).

edaphic grid -- A matrix of eight soil moisture classes and five soil nutrient classes, used by the MOF as an aid to stratification and as a device for information presentation (p. 36).

factor analysis -- An analytical technique in which the distribution of plots or attributes in a theoretical hyperspace is determined, in order to identify the principal axes of variation in the data (p. 87).

habitat component -- A life requisite, such as food or escape cover, for a given wildlife species (p. 25).

hierarchical classification system -- A classification system in which each level is an aggregation of those and only those classes in the level immediately below it (p. 7).

information system -- A system that stores, manipulates, and retrieves information, such as information about classification units (p. 3).

integrated classification system -- A classification system based on two or more biophysical components of the landscape, such as soil and vegetation (p. 5).

interpretive classification system -- See "technical classification system".

monothetic classification system -- See "single-factor classification system".

multifactor (polythetic) classification system -- A classification system which is based on several classification parameters for each class (p. 6).

natural (taxonomic) classification system -- A classification system which is designed to serve a large number of purposes (p. 5).

place-independent classification system -- A land classification system in which only characteristics that can be observed on a given site are used in the definition of units (p. 6).

place-specific classification system -- A land classification system in which characteristics other than those which can be observed on a given site -- such as attributes of adjacent units -- are used in the definition of units (p. 6).

plant alliance -- See p. 41.

plant order -- See p. 41.

polypedon -- Two or more contiguous pedons that are essentially alike in major profile characteristics (p. 55). A pedon is the smallest volume at the earth's surface that can be considered a soil, usually 1-several m^3.

polythetic classification system -- See "multifactor classification system".

presence -- Constancy (p. 39).

present ecological condition unit -- A landscape unit defined by present successional state, dominant tree species, and macrophysiognomy; forerunner of the vegetation landscape unit (p. 65).

releve -- Vegetation plot (p. 86).

similarity coefficient -- Any of a number of mathematical expressions of the degree of similarity between two plant communities or other units (p. 57).

single-factor (monothetic) classification system -- A classification system, generally technical, which is based on a single classification parameter (p. 6).

species significance -- A rating of the abundance of a plant species, based on percent cover (p. 38).

stage -- See p. 58.

taxonomic classification system -- See "natural classification system".

technical (interpretive) classification system -- A classification system in which objects are grouped according to their value for some specific purpose (p. 5).

vegetation landscape unit -- See p. 58.

vegetation type -- A unit of vegetation defined with the aid of the computer program COENOS, the members of which have a variable number of floristic characteristics in common with at least some other members of the same type (p. 57).

zonal ecosystem -- An ecosystem that is intermediate with respect to moisture and nutrient regime, and therefore expresses the regional climate better than ecosystems that are influenced by more extreme edaphic conditions (p. 35).

REFERENCES

Annas, R.M. 1977. Biogeoclimatic classification in the B.C. Forest Service. Pp. 25 - 28 in Ecological classification of forest land in Canada and northwestern U.S.A. Centre for Continuing Education, University of British Columbia, Vancouver.

Annas, R.M. and R. Coupe, eds. 1979. Biogeoclimatic zones and subzones of the Cariboo Forest Region. Ministry of Forests, Victoria. 103 pp.

Arlidge, J.W.C. and M. Kovats. 1969. Dissimilarity analysis. Unpublished computer program. Dept. of Lands, Forests, Water Resources, Victoria.

Asherin, D.A., H.L. Short, & J.E. Roelle. 1979. Regional evaluation of wildlife habitat quality using rapid assessment methodologies. Trans. N. Am. Wild. Nat. Resour. Conf. 44:404-424.

Bailey, R.G., R.D. Pfister and J.A. Henderson. 1978. Nature of land and resource classification -- a review. J. Forestry 76:650-655.

Block, J. 1977. Outdoor recreation resources of the northeast coal study area 1976 - 1977. Resource Analysis Branch Bulletin 4, Ministry of Environment, Victoria. (Not seen; cited by Harcombe 1978).

Blower, D. 1973. Methodology: land capability for ungulates in British Columbia. British Columbia Land Inventory, Victoria. 24 pp.

Brooke, R.C, E.B. Peterson and V.J. Krajina. 1970. The subalpine mountain hemlock zone. Ecology of Western North America. 2:148-349.

Brown, D.E. and C.H. Lowe. 1974. The Arizona system for natural and potential vegetation -- illustrated summary through the fifth digit for the North American Southwest. J. Ariz. Acad. Sci. 9, Suppl. 3. 56 pp. (Not seen; cited in Patton 1978).

Canada Soil Survey Committee. 1978. The Canadian System of Soil Classification. Publ. 1946. Agriculture Canada, Ottawa. 164 pp.

Ceska, A. 1975. COENOS 1: procedures for vegetation data processing in British Columbia. Biocon Research Ltd., Victoria. 30 pp. and app.

Ceska, A. and H. Roemer. 1971. A computer program for identifying species - releve groups in vegetation studies. Vegetatio 23:255-277.

Cline, M.G. 1949. Basic principles of soil classification. Soil Sci. 67:81-91. (Not seen, cited in Bailey et al. 1978).

Coulombe, H.N. 1978. Toward an integrated ecological assessment of wildlife habitat. Pp. 5-23 in Lund, H.G., V.J. LaBau, P.F. Ffolliott, and D.W. Robinson, coordinators, Integrated inventories of renewable natural resources: proceedings of the workshop. USDA For. Serv. Gen. Tech. Rep. RM-55.

Cowan, I. McT. 1945. The ecological relationships of the food of the Columbia blacktailed deer, Odocoileus hemionus columbianus (Richardson), in the coast forest region of southern Vancouver Island, British Columbia. Ecol. Monog. 15:109-139.

Daubenmire, R. 1973. A comparison of approaches to the mapping of forest land for intensive management. For. Chronicle 49:87-91.

Daubenmire, R. and J.B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington Agricultural Experiment Station. Tech. Bull. 60, Washington State University. 104 pp.

Davis, L.S. and J.A. Henderson. 1978. Many uses and many users: some desirable characteristics of a common land and water classification system. Pp. 13-34 in Marmelstein, A., ed., Classification, inventory and analysis of fish and wildlife habitat: the proceedings of a national symposium, U.S. Fish and Wildlife Service FWS/PB5-78/76.

Demarchi, D.A. 1979. Rangeland biophysical capability classification. Resource Analysis Branch Working Report, Victoria. 7 pp.

Demarchi, D.A. and B. Fuhr. 1979. Biophysical land capability for wildlife (ungulates) generation II. Resource Analysis Branch Working Report, Victoria. 12 pp. & app.

Demarchi, D.A., B.A. Pendergast and A.C. Stewart. 1981. Biophysical ungulate capability mapping in British Columbia. Pp. 49-56 in Miller, F.L. and A. Gunn, eds., Symposium on census and inventory methods for populations and habitats. Northwest Section, The Wildlife Society: Proceedings. Forest, Wildlife and Range Exp. Stn., University of Idaho, Moscow. 220 pp.

Ellis, J.A., J.N. Burroughs, M.J. Armbruster, D.L. Hallett, P.A. Korte, & T.S. Baskett. 1979. Appraising four field methods of terrestrial habitat evaluation. Trans. N. Am. Wildl. Nat. Resour. Conf. 44:369-379.

Environment and Land Use Sub-Committee. 1977. Preliminary environmental report on proposed transportation links and townsites. Victoria, 141 pp. & app.

Environment and Land Use Sub-Committee. 1978. Northeast coal study preliminary environmental report 1977-1978. Victoria. 173 pp. & app.

Fuhr, B. 1980. A wildlife habitat assessment of the Pine/Moberly area of northeastern British Columbia. Terrestrial Studies Branch Working Report, Victoria. 29 pp.

Garrison, G.A., A.J. Bjugstad, D.A. Duncan, M.E. Lewis and D.R. Smith. 1977. Vegetation and environmental features of forest and range ecosystems. USDA For. Serv. Agriculture Handbook 475. 68pp.

Gates, B.R. 1968. Deer food production in certain seral stages of the coast forest. M.Sc. Thesis, Univ. of B.C., Vancouver. 105 pp.

Hagmeier, E.M. 1975. Cluster analysis. Unpublished computer program. Dept. of Biology, University of Victoria.

Hall, F.C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington, USDA For. Serv. Reg. 6 Area Guide 3-1, Portland, Oregon. 62 pp. (Not seen, cited in Thomas 1979).

Harcombe, A. 1978. Vegetation resources of the northeast coal study area 1976-1977. Resource Analysis Branch, Kelowna. 46 pp. & app.

Harcombe, A. 1981. Legend for vegetation maps of Vancouver Island. Terrestrial Studies Branch, Kelowna. Preliminary draft.

Harcombe, A. n.d. Condensed key for the northeast coal vegetation types. Terrestrial Studies Branch, Kelowna. 46 pp. Preliminary draft.

Harcombe, A.P., C.E. Thompson, and R.F. Ferster. 1980. Vegetation of the Pine-Moberly area. (93P/13, 14, 15; 94A/2, 3, 4). Terrestrial Studies Branch Working Report, Kelowna. 23 pp.

Henderson, J.A. and L.S. Davis. 1978. ECOSYM: a classification and information system for wildland resource management. Pp 384-389 in Lund, H.G., V.J. LaBau, P.F. Ffolliott, and D.W. Robinson, coordinators, Integrated inventories of renewable natural resources: proceedings of the workshop. USDA For. Serv. Gen. Tech. Rep. RM-55.

Holroyd, G. 1980. The Biophysical Wildlife Inventory of Banff and Jasper National Parks. Pp. 37-43 in Taylor, D.G., ed., Land/wildlife integration. Ecological Land Classification Series 11. Environment Canada, Ottawa.

Houseknecht, S.J. 1976. Vegetational composition and regeneration in three forest associations after logging in the Coastal Western Hemlock Zone. M.Sc. thesis, Univ. of B.C. 224 pp.

Jones, G.W. 1975. Aspects of the winter ecology of black-tailed deer (Odocoileus hemionus columbianus Richardson) on northern Vancouver Island. M. Sc. thesis, Univ. of B.C., Vancouver. 78 pp.

Kerr, R.M. 1978. Current wildlife habitat inventory techniques and their use in habitat management. Pp. 125-130 in Lund, H.G., V.J. LaBau, P.F. Ffolliott, and D.W. Robinson, coordinators, Integrated inventories of renewable natural resources: proceedings of the workshop. USDA For. Serv. Gen. Tech. Rep. RM-55.

Kerr, R. 1980. Wildlife habitat inventory as accomplished by the United States Bureau of Land Management. Pp. 93-97 in Taylor, D.G., ed., Land/Wildlife integration. Ecological Land Classification Series 11. Environment Canada, Ottawa.

Klinka, K. 1977. Guide for the tree species selection and prescribed burning in the Vancouver Forest District. 2nd approximation. Ministry of Forests, Vancouver. 42 pp. & app.

Klinka, K., F.C. Nuszdorfer, and L. Skoda. 1979. Biogeoclimatic units of central and southern Vancouver Island. Ministry of Forest, Victoria. 120 pp.

Klinka, K., & R.E. Carter. 1980. Ecology and silviculture of the most productive ecosystems for growth of Douglas fir in southwestern British Columbia. Ministry of Forests, Land Management Report 6, Victoria. 12 pp.

Klinka, K., W.D. van der Horst, F.C. Nuszdorfer & R.G. Harding. 1980a. An ecosystematic approach to forest planning. Forestry Chronicle 56(3): 97-103.

Klinka, K., W.D. van der Horst, F.C. Nuszdorfer, and R.G. Harding. 1980b. An eco-systematic approach to a subunit plant: Koprino River Watershed Study. Ministry of Forests, Land Management Report 5, Victoria. 118 pp.

Klinka, K., M.C. Feller, and L.E. Lowe. 1981a. Characterization of the most productive ecosystems for growth of Pseudotsuga menziesii var. menziesii in southwestern British Columbia. Ministry of Forests, Suppl. to Land Management Report 6, Victoria. 49 pp.

Klinka, K., R.N. Green, R.L. Trowbridge and L.E. Lowe. 1981b. Taxonomic classification of humus forms in ecosystems of British Columbia. First approximation. Ministry of Forests, Land Management Report 8, Victoria. 54 pp.

Klinka, K. and S. Phelps. n.d. Environment - vegetation tables by a computer program: introduction. Faculty of Forestry, University of British Columbia, Vancouver. 24 pp.

Kojima, S. and V.J. Krajina. 1975. Vegetation and environment of the coastal western hemlock zone in Strathcona Provincial Park, British Columbia, Canada. Syesis 8 (Suppl. 1): 1-123.

Korelus, V.J. 1977. Review of Pacific Logging Company's forest site mapping program and methodology. Pacific Logging Company, Victoria. Unpublished. 22 pp. & app.

Krajina, V.J. 1965. Biogeoclimatic zones and biogeocoenoses of British Columbia. Ecol. Western N. Amer. 1:1-17.

Krajina, V.J. 1969. Ecology of forest trees in British Columbia. Ecol. Western N. Amer: 2:1-147.

Krajina, V.J. 1973. Biogeoclimatic zones of British Columbia. British Columbia Ecological Reserves Committee, Department of Lands, Forests, and Water Resources, Victoria. 1:1,900,800 coloured map; 94 x 77 cm.

Kuchler, A.W. 1964. Manual to accompany the map, potential natural vegetation of the conterminous United States. Am. Geogr. Soc. Spec. Publ. 36. New York. 152 pp. (Not seen; cited in Thomas 1979).

Macnaughton-Smith, P. 1965. Some statistical and other numerical techniques for classifying individuals. Home Office Research Report 6, Her Majesty's Stationery Office, London. 33 pp.

Major, J. 1951. A functional, factorial approach to plant ecology. Ecology 32:392-412.

Moir, B.C. 1979. Wildlife Report: Tsitika River. MacMillan Bloedel Ltd., Nanaimo. 10 pp & app.

Moir, B.C. 1980. Blacktail deer use of timber stands on south Vancouver Island. MacMillan Bloedel Ltd., Nanaimo. 20 pp. & app.

Moon, D.E. and C. Selby. 1981. Provisional guide to soil and vegetation units in the Power River Watershed. Agriculture Canada, Vancouver, n.p. Preliminary draft.

Mueller-Dombois, D. 1959. The Douglas-fir forest associations in Vancouver Island in their initial stages of secondary succession. Ph.D. thesis. University of British Columbia, Vancouver. 570 pp.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York. 547 pp.

Nelson, D., G.A. Harris and T.E. Hamilton. 1978. Land and resource classification -- who cares? J. Forestry 76:644-646.

Oswald, E.T. 1972. Vegetation of Nimpkish Valley pilot project area: a preliminary analysis. Pacific Forest Research Centre, Can. For. Serv. Internal Report BC-40. 20 pp.

Packee, E.C. 1974. The biogeoclimatic subzones of Vancouver Island and the adjacent mainland and islands (revised). Forest Research News No. 1, MacMillan Bloedel. 9 pp. & app.

Patton, D.R. 1978. RUN WILD: a storage and retrieval system for wildlife habitat information. USDA For. Serv. Rocky Mountain For. and Range Exp. Stn. Gen. Tech. Rep. RM-51. Fort Collins, CO. 8 pp.

Perret, N.G. 1970. Land capability classifcation for wildlife. Canada Land Inventory Report No. 7, Environment Canada, Ottawa. 30 pp.

Pfister, R.D. & S.F. Arno. 1980. Classifying forest habitat types based on potential climax vegetation. Forest Science 26:52-70.

Prescott, W.H. 1980. Integrating wildlife and biophysical land inventories in the national parks of Atlantic Canada. Pp. 61-73 in Taylor, D.G., ed., Land/wildlife integration. Ecological Land Classification Series 11. Environment Canada, Ottawa.

Rafiq, M. 1980. Lardeau Flats: vegetation resources with interpretations for wildlife management. Ministry of Environment Working Report. Kelowna. 40 pp.

Resource Analysis Branch. 1977a. Preliminary report of vegetation of the Tumbler Ridge townsite area. Ministry of Environment, Victoria. (Draft copy; not seen; cited by Harcombe 1978).

Resource Analysis Branch. 1977b. Wildlife resources of the northeast coal study area 1976-1977. RAB Bulletin 6, Victoria. 58 pp. & app.

Resource Analysis Branch. 1979. Wildlife resources of the northeast coal study area 1977-1978. RAB Bulletin 12, Victoria.

Resource Analysis Unit. 1976. Terrain classification system. Environment and Land Use Committee Secretariat, Victoria. 56 pp.

Rochelle, J.A. 1980. Mature forests, litterfall and patterns of forage quality as factors in the nutrition of black-tailed deer on northern Vancouver Island. Ph.D. thesis, Univ. of B.C., Vancouver.

Schmidt, R.L. 1977. Activities of the B.C. Forest Service in ecological classification. Pp. 13-17 in Ecological classification of forest land in Canada and northwestern U.S.A. Centre for Continuing Education, University of British Columbia, Vancouver.

Scoullar, K. 1981. Developing a wildlife-habitat management system. Integrated Wildlife/Intensive Forestry Research Program problem analysis. 53 pp. Preliminary draft.

Selby, C. 1980. Vegetation report for the Power River Watershed. Ministry of Forests, Planning Branch, Vancouver. n.p. Preliminary draft.

Senyk, J.P. 1977. Ecological land classifcation activities -- Canadian Forestry Service, Victoria. Pp. 29-34 in Ecological classification of forest land in Canada and northwestern U.S.A. Centre for Continuing Education, University of British Columbia, Vancouver.

Sokal, R.R. 1974. Classification: purposes, principles, progress, prospects. Science 185:1115-1123.

Spilsbury, R.H. and D.S. Smith. 1947. Forest site types of the Pacific Northwest. Dept. of Land and Forests, B.C.F.S. Techn. Publ. T30. 46 pp.

Stelfox, H. 1980. Mapping critical wildlife habitat in agricultural Saskatchewan. Pp. 51-59 in Taylor, D.G., ed., Land/Wildlife integration. Ecological Land Classification Series 11. Environment Canada, Ottawa.

Taylor, D.G., ed. 1980a. Land/Wildlife integration. Ecological Land Classification Series 11. Environment Canada, Ottawa. 160 pp.

Taylor, D.G., ed. 1980b. Working group sessions. Pp. 121-131 in Taylor, D.G., ed., Land/wildlife integration. Ecological Land Classification Series 11. Environment Canada, Ottawa.

Thomas, J.W. ed. 1979. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA Forest Service Agriculture Handbook No. 553. 512 pp.

Thompson, C.E., A.P. Harcombe, and R.F. Ferster. 1980. Explanatory legend for vegetation maps of the Pine-Moberly area (NTS: 93P: 13, 14, 15; 94A 2, 3, and 4). Ministry of Environment Working Report, Kelowna. 21 pp.

Toovey, J.W. 1977. Activities of forest companies in British Columbia. Pp. 35-40 in Ecological classification of forest land in Canada and northwestern U.S.A. Centre for Continuing Education, University of British Columbia, Vancouver.

Tsitika Planning Committee. 1978. Tsitika Watershed Integrated Resource Plan -- Summary Report.

United States Fish and Wildlife Service. 1980a. Habitat as a basis for environmental assessment (101 ESM). Division of Ecological Services, Washington, D.C. n.p.

United States Fish and Wildlife Service. 1980b. Habitat Evaluation Procedures (102 ESM). Division of Ecological Services, Washington, D.C. n.p.

van Barneveld, J.W. 1976. Vegetation: inventory methodology, availability, and interpretation. In Natural resource inventory. Centre for Continuing Education, University of British Columbia, Vancouver. n.p.

van Barneveld, J.W. 1978. The vegetation component in ecological land classification. Canadian Committee on Ecological (Bio-physical) Land Classification Newsletter 5:1-4.

Vold, T., R. Maxwell, and R. Hardy. 1977. Biophysical soil resources and land evaluation in the northeast coal study area: 1976-1977. 2 vol. Resource Analysis Branch, Bulletin 7, Ministry of the Environment, Victoria. (Not seen; cited by Harcombe 1978).

Vold, T., R.F. Ferster, T.K. Ovanin, R.D. Marsh, and G.P. Woods. 1980. Soil and vegetation resources of the Pend-d'Oreille Valley, B.C. Assessment and Planning Division Bulletin 2, Victoria. 92 pp. & app.

Wali, M.K. and V.J. Krajina. 1973. Vegetation-environment relationships of some sub-boreal spruce zone ecosystems in British Columbia. Vegetatio 26:237-381.

Walmsley, M.E. and J. van Barneveld. 1977. Biophysical land classification techniques: the application to ecological classification of forest land in British Columbia. Pp. 41-119 in Ecological classification of forest land in Canada and northwestern U.S.A. Centre for Continuing Education, University of British Columbia, Vancouver.

Walmsley, M., G. Utzig, T. Vold, D. Moon, & J. van Barneveld. 1980. Describing ecosystems in the field. RAB Technical Paper 2. Ministry of Environment and Ministry of Forests. Victoria, B.C. 226 pp.

Whelan, J.B., A.R. Tipton, J.F. Williamson, P.R. Johansen, J.P. McClure, & N.D. Cost. 1979. A comparison of three systems for evaluating forest wildlife habitat. Trans. N. Am. Wild. Nat. Resour. Conf. 44:392-403.

Williams, W.T. 1967. Numbers, taxonomy, and judgment. Bot. Rev. 33:379-386.

APPENDIX 1

DATA FORMS USED BY GOVERNMENT AGENCIES

SITE DESCRIPTION FORM

FORM NUMBER [ ] - 8 0

PAGE 1 OF _____

Mark a cross (X) over parameter number when not considered.
Mark a slash (/) over parameter number when not found. Parameters which must be filled in are circled.

(1.) Proj. ID _____ 2. Plot No. _____ (3.) Date (Y/M/D) _____

(4.) NTS Sheet _____ (5.) Lat. ° ' " ± (6.) Long. ° ' " ±

7. Location _____

8. Photo number and Co-ord. flight line _____ photo no. _____ X _____ Y _____

(9.) Aspect _____ ° (10.) Slope _____ percent (11.) Elevation _____ ± metres

12. Terrain classification Year _____

Terrain Texture	Genetic Material	Qual. Desc.	Surface Exp.	Mod. Proc.

13. Physiographic Subdivision _____

14. Zone/Subzone _____ classification system _____

15. Landscape Type _____ classification system _____

16. Vegetation Type _____ classification system _____

17. Soil Classif. _____ Year _____ Phase _____ Family P.S. _____

18. Plot representing _____

(19.) Site position macro
a. apex
b. face
c. upper slope
d. middle slope
e. lower slope
f. valley floor
g. plain

(20.) Site position meso
a. crest
b. upper slope
c. middle slope
d. lower slope
e. toe
f. depression
g. level

(21.) Site surface shape
a. concave
b. convex
c. straight

(22.) Microtopography
a. smooth
b. micro mounded
c. slightly mounded
d. moderately mounded
e. strongly mounded
f. severely mounded
g. extremely mounded
h. ultra mounded

23. Meso slope length _____ m 24. Meso up-slope length _____ m

25. Site position diagram (refer to data form no. _____)

photo roll no. _____
photo no. _____
Direction ←→
scale [ ] 1 = _____

(26.) Exposure type
a. not applicable
b. wind
c. insolation
d. frost
e. cold air drainage
f. saltspray
g. atmospheric toxicity
z. other _____

Comments: _____

27. Ecological Moisture Regime
a. very xeric
b. xeric
c. subxeric
d. submesic
e. mesic
f. subhygric
g. hygric
h. subhydric
i. hydric

28. Nutrient Regime
a. oligotrophic
b. submesotrophic
c. mesotrophic
d. permesotrophic
e. eutrophic
f. hypereutrophic

29. Soil Temperature Class
a. extremely cold
b. very cold
c. cold
d. cool
e. mild

30. Soil Moisture Subclass
a. xeric
b. arid
c. subarid
d. semiarid
e. subhumid
f. humid
g. perhumid
h. subaquic
i. aquic
j. peraquic

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31. Soil drainage
a. rapidly
b. well
c. mod. well
d. imperfectly
e. poorly
f. very poorly

32. Perviousness
a. rapidly
b. moderately
c. slowly

33. Free Water
a. present
b. absent

34. Flood hazard
a. frequent and irregular
b. frequent
c. may be expected
d. rare
e. no hazard

35. Depth to (cm)
a. water table _____
b. rooting (effective) _____
c. root restricting layer _____
d. frozen layer _____
e. bedrock _____
f. carbonate _____
g. salinity _____

36. Bedrock type 37. Bedrock structure

38. Coarse fragment lithology
a. type (in order of dominance) b. mixed

39. Successional Status
Present Stage: PS, YS, MS, OS, YEC, YCC, MCC, MEC, DC, NV
Expected climax _____
Rate of succession
a. very slow
b. slow
c. normal
d. rapid
e. very rapid

40. Factors Influencing Stand Establishment

42. Humus Form Class. _____
Variants _____

41. Veg. Plot Dim. _____ (metres)
Shape _____ Area _____

44. Profile Status
a. modal
b. variant
c. taxadjunct
d. undecided

45. Profile Deviation
a. none
b. solum thickness
c. colour
d. texture
e. drainage
f. chemical
g. horizon thickness
z. other _____

46. Soil Mapping Unit
a. series
b. family
c. associate
d. association
e. catena
f. complex
g. land system
h. land type
z. other

43. Surface Substrate

SUBSTRATE	% COVER
Decaying Wood	
Bedrock	
Cobbles and Stones	
Mineral Soil	
Organic Matter	
Water	
Total	100%

47. Soil name _____ 48. Associated soil _____

49. Profile No. _____ (50) Project Coordinator _____ (51) Agency _____

(52) Type of Soil Sample
A. Sampled
1. Chemical
a. full
b. partial
2. Physical
a. full
b. partial
B. No Sample

53. Veg. Sampling Tech. _____

54. Notes on Site Description _____

VEGETATION DESCRIPTION FORM

FORM NUMBER | | | | | - | 8 | 0 |

PROJECT I.D. _____ PLOT NO. _____ PAGE _____ OF _____

SURVEYOR _____

1. FLORISTIC LIST specify entries here	2. STRATUM											6. NOTES				
	Veteran	Dominant A1 Trees	Main A2 Canopy	A3 Trees	Total Trees	Tall B1 Shrubs	Low B2 Shrubs	Total Shrubs	C Herbs	Mosses, Lich., D Liv. Seedlings	All Strata					
3. Height of top of strata (m)																
Number of dead snags																
4. Total percentage cover of each layer																
5. SPECIES LIST																

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DURABAR WATERPROOF

7. Comments on Vegetation Characteristics:

_____

_____

_____

_____

MENSURATION FORM

FORM NUMBER - 80

PROJECT I.D. _____ PLOT NO. _____ PAGE _____ OF _____

SURVEYOR _____

PLOT NO. | BAF | D.B.H. UNIT

C | | A

TREE NO.	TOTAL HEIGHT (Metres)	SPECIES	D.B.H. (Centimetres)	TREE CLASS	PATH. REMARKS: CONK	BLIND CONK	SCAR	FORK or CROOK	FROST CRACK	WHISTLETOE	ROTTEN BR	D = B TOP	CROWN CLASS	STAND AGE (for MAI)
1	10 11 12	13 14	15 16 17 18	19	20	21	22	23	24	25	26			78 79 80
	.		.											

TREE CLASS
1 Merchant
2 Support
3 Good Potential
4 Good Useless
5 Veteran

PATH CODE
1
2
3
4
5
6
7

CROWN CLASS (C/C)
1 Dominant
2 Co-Dominant
3 Intermediate
4 Suppressed

PLOT NO. | BAF | D.B.H. UNIT

C | | B

TREE NO.	TOTAL HEIGHT (Metres)	SPECIES	D.B.H. (Centimetres)	TREE CLASS	PATH. REMARKS: CONK	BLIND CONK	SCAR	FORK or CROOK	FROST CRACK	WHISTLETOE	ROTTEN BR	D = B TOP	CROWN CLASS	STAND AGE (for MAI)
	10 11 12	13 14	15 16 17 18		19	20	21	22	23	24	25	26		78 79 80
	.		.											

TREE NO.	TOTAL HEIGHT	SPEC.	D.B.H.	C / C	TOTAL AGE	AGE CALCULATIONS: COUNT. AGE	B.H.	COR.	SUP.	HEIGHT CALCULATIONS: TOP	BOT.	TOTAL	S.D.	SLOPE	H.D.	HT.	COR.
	.		.														

WILDLIFE AND RANGE FORM

FORM NUMBER | | | | | | - | 8 | 0 |

PROJECT ID _____ PLOT NO. _____ PAGE____ OF____

SURVEYOR _____

1. Utilization of Browse Plants (recorded on Vegetation Form)

   a. Utilization Rating
   b. Utilization Form Class

2. Ungulate Pellet Group Counts

   a. Method A
   b. Method B
   c. Method C
   d. Other Method _____

UNGULATE SPECIES	SUBPLOT 1	2	3	4	5	TOTAL

3 Wildlife List	4 Wildlife Sign	5 Habitat Characteristic	6 Avail. Food Source	7 Season of Use	8 Comments

9. Utilization of Forage Plants

   a. No Utilization
   b. Trace (1-5%)
   c. Light (6-25%)
   d. Moderate (26-50%)
   e. Heavy (>50%)

10. Range Condition

    a. Excellent
    b. Good
    c. Fair
    d. Poor
    e. Not determined

11. Productivity

Plant Group	Estimated Green Wt. kg/ha	Measured Green Weight kg/ha	Air-Dry Weight kg/ha	Oven-Dry Weight kg/ha
Grasses, forbs				
Browse species				
Other (specify)				

12. General Comments on Wildlife and Range

_____

_____

_____

_____

_____

_____

HUMUS FORM AND ORGANIC SOIL DESCRIPTION

(B.C. Ministry of Forests, 1981)

Project I.D. _____ Plot No. _____ Form Number

Surveyor _____ Page ____ of ____ Taxon _____

1	2	3	4		5		6	7		8	9	10	11	12			13	14	15								
HORIZON								COLOUR		FABRIC				MATERIAL COMPOSIT					ROOTS 1				ROOTS 2				
Desig	Lab No	Depth	Thickness Min	Max	Boundary Distr	Form	MOIST STAT	Aspect	Munsell not	Structure	Consistence	Character	TEXTURE	Kind 1	2	Decom	PYRO INDEX	VON POST SCALE	Ab	Size	Orig	Distr	Ab.	Size	Orig	Distr.

1	16				17								18	19	20
Horizon Desig.	NON-CONFORMING MATERIALS				SOIL BIOTA								pH	BULK DENSITY	Schematic Humus Form Profile
	Kind	Distr.	Size	Ab.	Flora Kind	Distr.	Ab.	Fauna Kind	Size	Ab.	Droppings Dist	Ab			

NOTES _____

SOIL TEMP	
cm	°C
0	
10	
50	
100	

Canadian Cartographic

APPENDIX 2

PERSONNEL CONTACTED

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